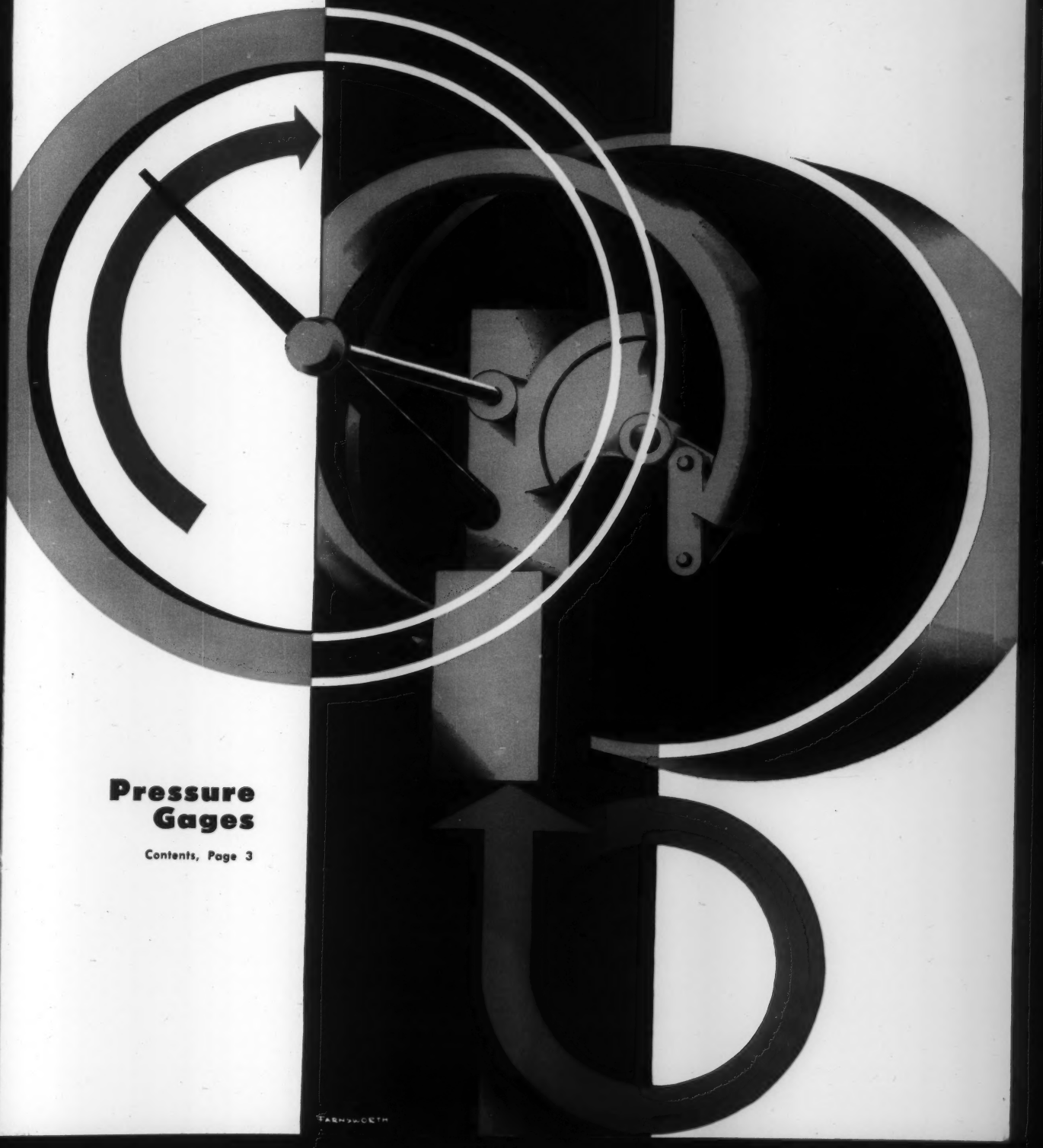
JULY 23, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Pressure Gages

Contents, Page 3

ASCO Close-Differential Relays provide dependable, low-cost protection from under and over voltage.

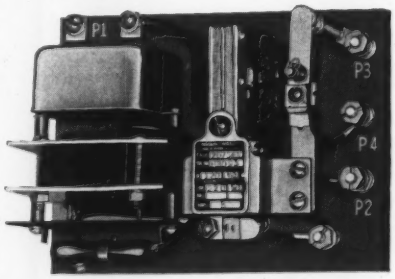
When a motor runs on low voltage for an extended period of time, burnout and fire may result. This can be costly in both down-time and damage to equipment.

You can protect your motors with ASCO Close-Differential Relays. They offer economical, dependable protection even when motor feedback conditions prevent ordinary potential relays from detecting changes in voltage. ASCO Close-Differential Relays respond to a 2% variation in voltage; protect motors when low voltage or over voltage conditions occur.

Because they combine sensitivity with rugged construction, ASCO Relays are providing low-cost protection in a wide variety of applications.

For example, in some oil burner installations, ASCO Relays help prevent explosions due to under voltage. In these installations, when under voltage occurs, ASCO Relays prevent oil build-up in the pit by detecting this low voltage condition, and causing oil flow to be cut off immediately. Otherwise on under voltage the oil would build-up in the pit since the ignition system would not fire. This excess oil could result in an explosion when voltage is restored and the ignition system fires.

Find out how the ASCO Close-Differential Relay can protect your equipment. Send for Catalog 57-S4 describing the complete line of ASCO Relays.



ASCO Close-Differential A-C Relay operates on 2% variation in voltage—features positive action, quiet operation, power relay type contacts.

Dependable control by ASCO is available from representatives and distributors in all principal cities.

Automatic Switch Co.

54 A Hanover Road, Florham Park, New Jersey • Frontier 7-4600

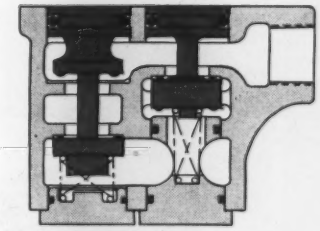
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

Circle 401 on Page 19

a basic Ross valve building block

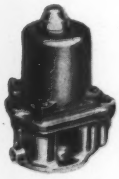
4-way inline mounted valve body



- **Compact—saves space**
- **Ross quality**
- **Costs much less than base mounted 4-way**

Lots of designers use this valve where they must save space. It was designed specifically for compactness! Others use it to save money *without sacrificing* quality—when J.I.C. allows the usage of an inline valve, it meets J.I.C. specs. It's a unit of the Ross Skyline series which features modular construction, so it can be actuated with any Skyline series head. Ross poppet construction means pressure assists the seal, and short poppet travel gives faster response. On most applications it outlives the machine—and frequently doesn't even require maintenance. Write for Bulletin 321.

* WHITEMODEL SPOOL SOLENOID


* GOLDMODEL OIL-IMMERSED SOLENOID

* SILVERMODEL JIC SPOOL SOLENOID

GREENMODEL DOUBLE SOLENOID MOMENTARY

BLUEMODEL AIR OPERATED

BLUEMODEL AIR-OPERATED MOMENTARY ADAPTOR

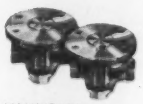
BLUEMODEL AIR-OPERATED TIMED IN

BLUEMODEL AIR-OPERATED TIMED-OUT

*THIS AIR INDEX ADAPTOR CONVERTS THESE HEADS TO MOMENTARY ACTION

"every head meets every body at this gasket"

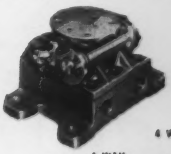
ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES


STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED

3 WAY NORMALLY OPEN NORMALLY CLOSED

4 WAY

3 WAY NORMALLY OPEN NORMALLY CLOSED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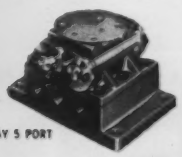
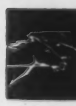

4 WAY 5 PORT



ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle 404 on Page 19

30 times the belt-life on belt-wrecking job

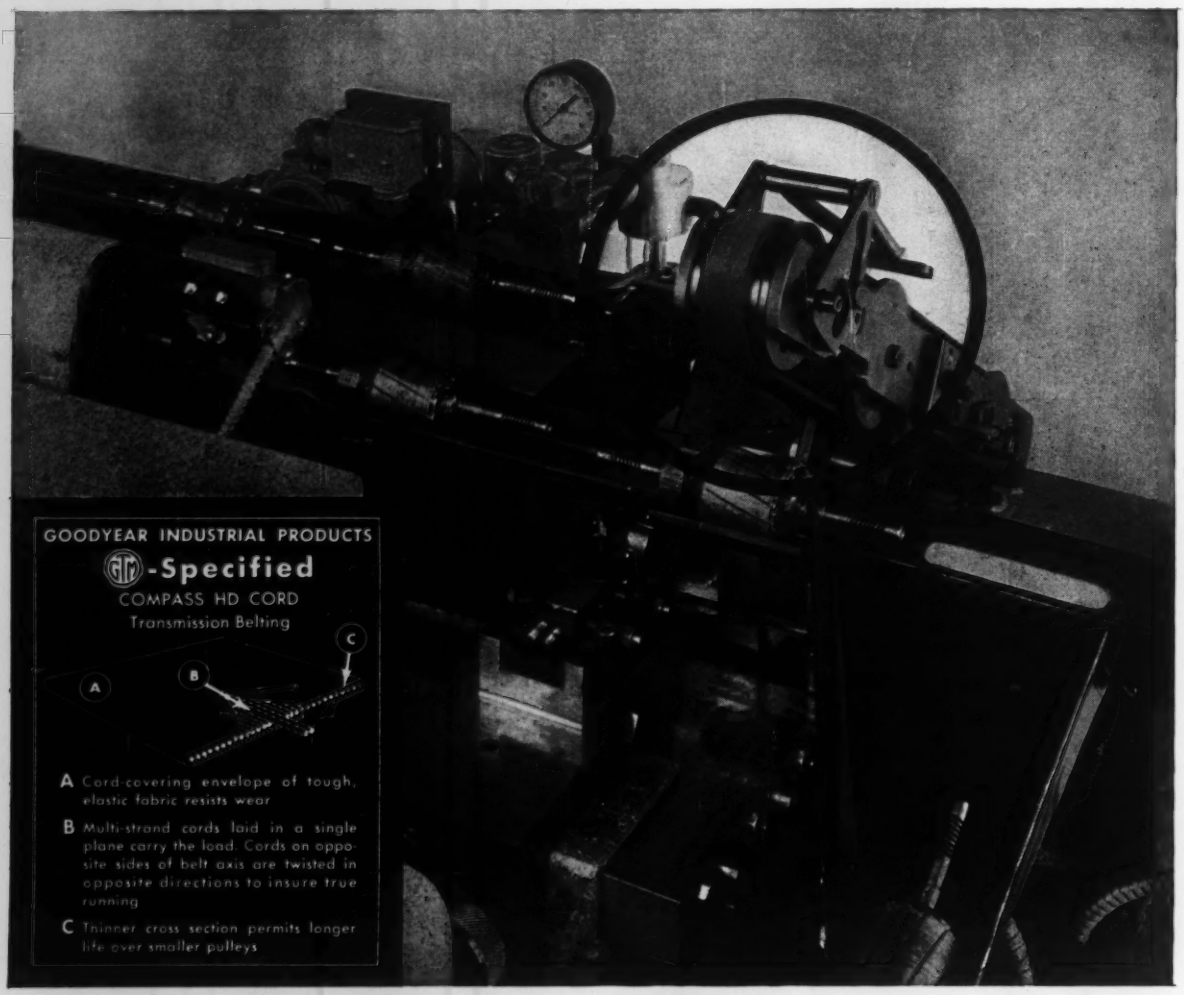
It was an "impossible" belting job: Pulleys were only 2- to 3-inch diameter. Centers were short. Conditions were oily. And to top it all, the transmission belt was also used as a brake on this new-type turning machine.

Its Midwestern designers hopefully tried out several types of belting construction. But a single day was the best service they could get from any belt—until they talked it over with the G.T.M.–Goodyear Technical Man.

His recommendation: a super-tough COMPASS HD CORD belt. And how did it work? Users of this machine are getting 30- to 60-days' service per belt – even when the machine is turning out 800 commutators an hour.

And that's one more case where the G.T.M. has supplied important help in getting a good new idea off the ground. If you'd like to turn loose his famed problem-solving ability on a project of yours, contact him through your Goodyear Distributor—or by writing Goodyear, Industrial Products Division, Akron 16, Ohio.

IT'S SMART TO DO BUSINESS with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."


GOODYEAR INDUSTRIAL PRODUCTS
GTM-Specified
COMPASS HD CORD
Transmission Belting
A
B
C
A Cord-covering envelope of tough, elastic fabric resists wear
B Multi-strand cords laid in a single plane carry the load. Cords on opposite sides of belt axis are twisted in opposite directions to insure true running
C Thinner cross section permits longer life over smaller pulleys

COMPASS TRANSMISSION BELTS BY

GOODYEAR

THE GREATEST NAME IN RUBBER

Compass–T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Watch "Goodyear Theater" on TV every other Monday evening.

Circle 405 on Page 19

Front Cover: Fluid pressure hasn't "exploded" the gage on this issue's front cover; it's just George Farnsworth's way of showing how a pressure gage operates. Factors to consider in selecting a pressure gage are reviewed in W. L. Buffenmyer's article starting on Page 118.

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MACHINE DESIGN

July 23, 1959
Volume 31 — No. 15

Not for Amateurs 109
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Powder-metal heat sink cools Mercury capsule—static-control component operates like human nerve cell—pure molybdenum sheet can now be cold worked—jacking system positions oil-drilling barge—Mach 3 speed is predicted for next generation of jetliners—standing wave of solder makes high-strength connections—pressure tests of Convair-880 simulate 20 years of flight—Atomic clock will orbit earth to check Einstein theory.

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Toggle-action contacts give positive two-way switching—"guillotine" rotor controls multiple pressure channels—external clutch mounting provides maximum cooling—grease-filled slip clutch drives friction wheel—remote latch operation is provided by vacuum-actuated linkage—phased elliptical rollers convey bulk materials.

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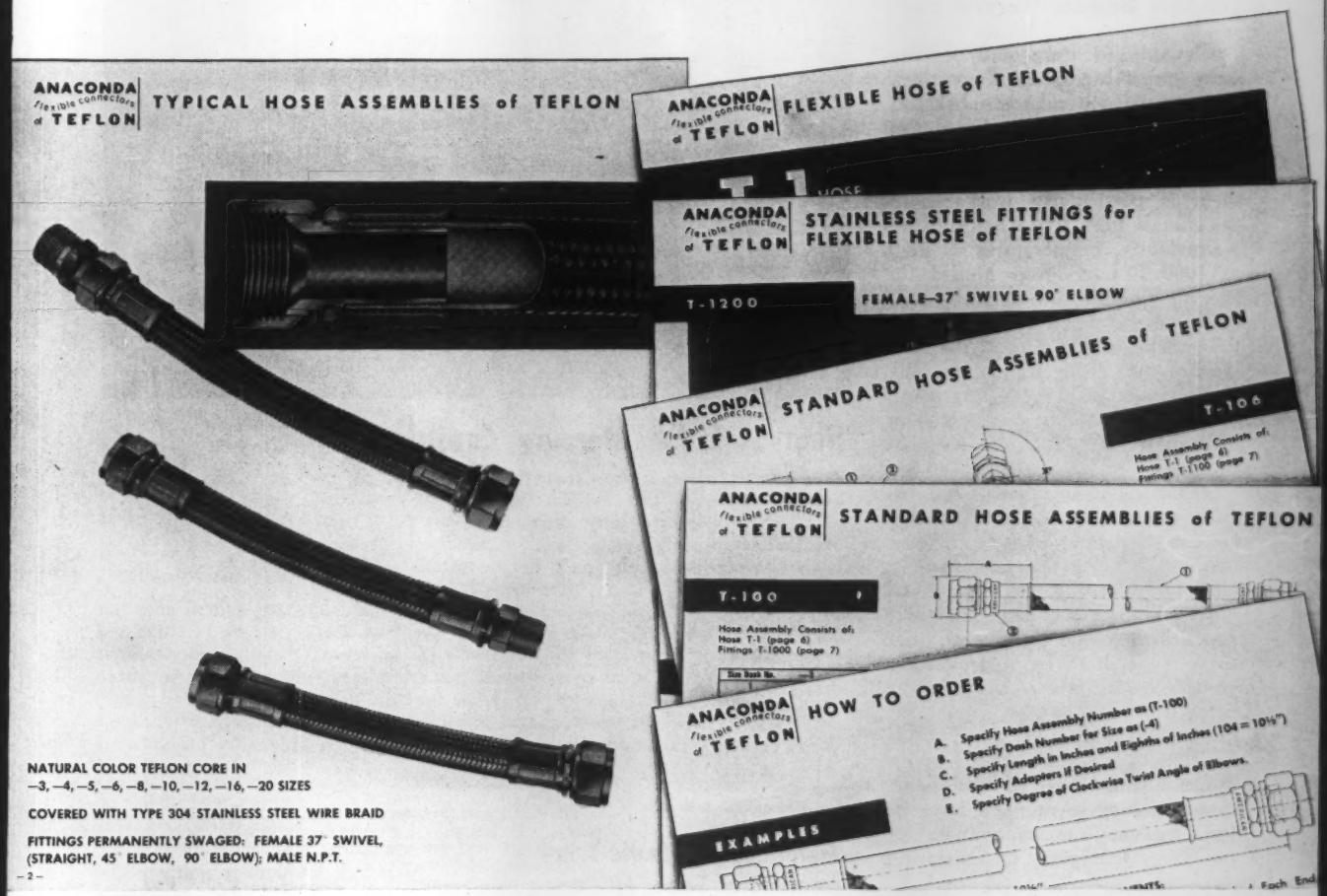
NEW CATALOG

. . . ON ANACONDA FLEXIBLE CONNECTORS OF TEFLON*


ANACONDA flexible connectors of TEFLON
TYPICAL HOSE ASSEMBLIES of TEFLON
NATURAL COLOR TEFLON CORE IN
—3, —4, —5, —6, —8, —10, —12, —16, —20 SIZES
COVERED WITH TYPE 304 STAINLESS STEEL WIRE BRAID
FITTINGS PERMANENTLY SWAGED: FEMALE 37° SWIVEL, (STRAIGHT, 45° ELBOW, 90° ELBOW); MALE N.P.T.
—2—
ANACONDA flexible connectors of TEFLON
FLEXIBLE HOSE of TEFLON
T-1
ANACONDA flexible connectors of TEFLON
STAINLESS STEEL FITTINGS for FLEXIBLE HOSE of TEFLON
T-1200
FEMALE—37° SWIVEL 90° ELBOW
ANACONDA flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-106
Hose Assembly Consists of:
Hose T-1 (page 6)
Fittings T-1100 (page 7)
ANACONDA flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-100
Hose Assembly Consists of:
Hose T-1 (page 6)
Fittings T-1000 (page 7)
ANACONDA flexible connectors of TEFLON
HOW TO ORDER
A. Specify Hose Assembly Number as (T-100)
B. Specify Dash Number for Size as (-4)
C. Specify Length in Inches and Eighths of Inches (10⅜ = 10⅜")
D. Specify Adapters if Desired
E. Specify Degree of Clockwise Twist Angle of Elbows.
EXAMPLES

Hose assemblies of Teflon, like those illustrated above, were designed to help meet tough problems—temperature extremes, corrosion, high pressure in conveying chemicals, searching liquids, fuel, oils, oxygen, steam—or in hydraulic and conduit applications. A standard assembly may handle your job, help you cut costs. If not, our laboratory and test facilities, as well as engineering services, are available to help in design and development of hose assemblies for special applications. Let us show you how we can help you handle tough problems with Anaconda Flexible Connectors of Teflon. Send for catalog today. 59126

*Teflon is a DuPont trademark for TFE—fluorocarbon resin

WHEREVER CONNECTORS MUST MOVE

ANACONDA® METAL HOSE

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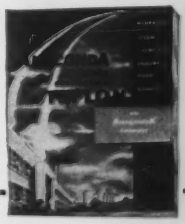
An easy-to-use 16-page book with complete data, drawings, photos



Anaconda Metal Hose Division
The American Brass Company MD
Waterbury 20, Conn.

Please send me your free 16-page catalog of Anaconda Flexible Connectors of Teflon, No. TC-101

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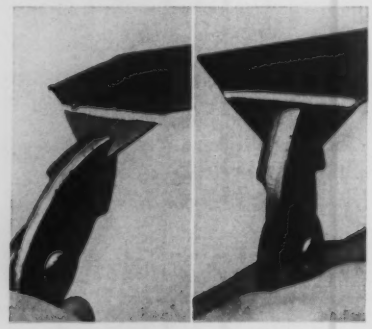
Pure Molybdenum Sheet Can Now Be Cold Worked

CLEVELAND — Pure molybdenum sheet that is highly ductile at room temperature will take the heat off many metalworking jobs. Developed by General Electric's Lamp Metals and Components Dept., the new sheet is particularly workable in thicknesses from 0.025 to 0.125 in.

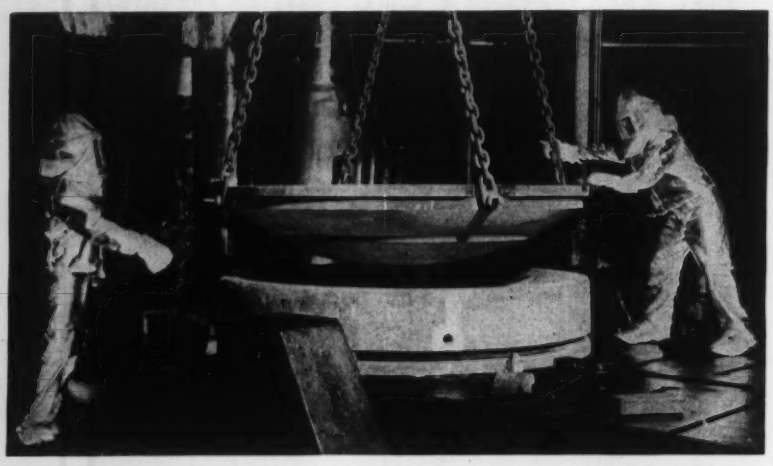
Previously, temperatures as high as 1000 F have been needed for forming molybdenum parts. At lower temperatures, the material's brittle crystals resisted any of the conventional forming techniques.

Because of its high melting point, low vapor pressure, and excellent mechanical strength at elevated temperatures, molybdenum is a key material in many defense and industrial applications. It should now become even more of a key defense material because the new sheet is ideal for punching and deep-drawing operations, says G.E., and may make possible the forming of thick sections of sheet by hydroforming techniques in which heat cannot be used.

The new sheet is reported to exhibit five times the ductility of ordinary "moly" sheets, bend better than ordinary sheets, and have far less tendency to delaminate on punching, stamping, and shearing.



Ordinary molybdenum sheet at room temperature (left) can be bent only about 20 degrees without either cracking or breaking. The highly ductile sheet of the same thickness and at the same temperature (right) withstands a right-angle bend without damage.



Heat Sink for Mercury Capsule

Keeping the first spaceman from frying is the job of the beryllium heat sink proposed for the Project Mercury capsule. To produce this sink, Brush Beryllium Co., Cleveland, simultaneously applied vacuum, heat, and pressure to beryllium powder, forming a beryllium billet 62 in. in diameter—one of the largest ever made by powder metallurgy techniques. After preliminary machining, the billet, encased in steel for high-temperature forging, was shipped to Aluminum Co. of America's Cleveland works. There it was heated to 2000 F in a special furnace. A huge manipulator then placed the piece on a preheated die where a 50,000-ton press squeezed it into a saucer-shaped disc, 80 in. across by 3 in. thick. After precision finishing and ultrasonic inspection, the disc will be forwarded to McDonnell Aircraft Corp., St. Louis, prime contractor for the Project Mercury manned vehicle.

Metal-Coated Plastic Trims Interiors of Some '60 Cars

Improved Vacuum Metallizing Gives Bright, Durable Surface

DETROIT—A new kind of auto trim will add brilliance and color to future autos. Scheduled for limited use on some of the 1960 cars, the trim will receive wider use on the 1961 models.

Produced under ultra-low pressures by adding a metal coating to the surface of a plastic, the trim is lighter, brighter, and cheaper than chrome-plated metal, and can be colored to match auto interiors. It is now suitable for automotive uses because of new developments by National Research Corp., Boston, in the vacuum metallizing of plastics.

Although known for many years, vacuum metallizing has previously been unsuitable for materials that must withstand weather and hard wear. Shortcomings of the earlier process have now been eliminated by new equipment and new techniques. Improved lacquers (used both as primer and protective coats in the process) have also been developed. A special thick-film process now permits weight and cost savings by the substitution of plastic for metal trim wherever strength is not required.

The 1960 models will use metallized plastics only for interior trim and for functional parts such as horn buttons, speedometer dials, dashboard instruments, arm rests, and similar items.

Circle 407 on Page 19→

. . . Fluid Power news

REPORT NO. 12,105 NEW SECTION AND DRIVE IMPROVES PRODUCT

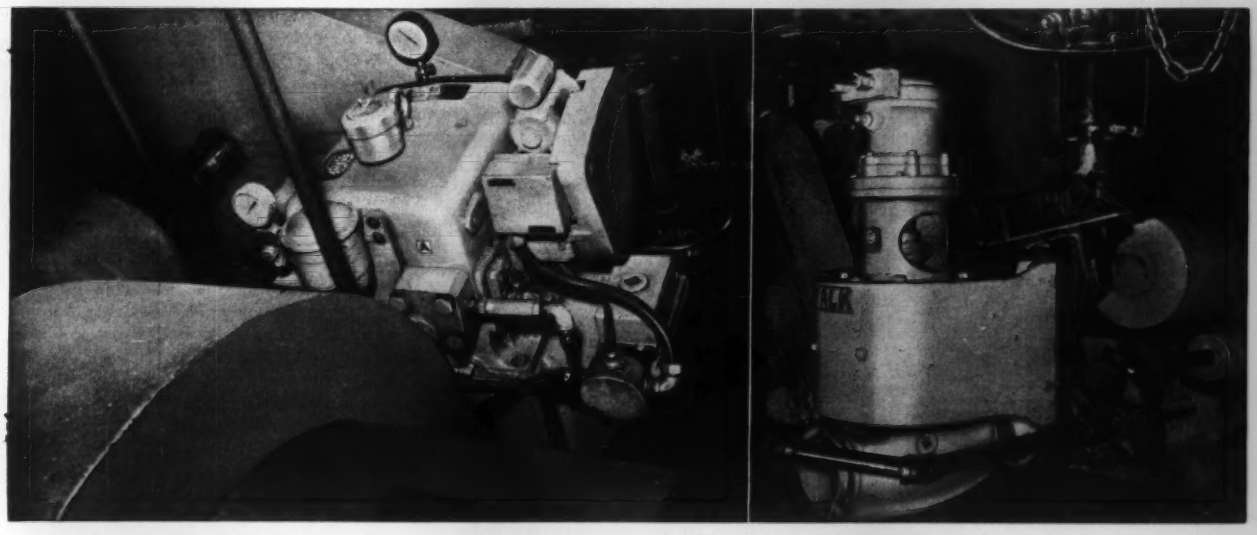
From Oilgear Application-Engineering Files

HOW OILGEAR HELPED SOLVE DRIVE PROBLEM FOR A NEW PAPER MACHINE SECTION

CUSTOMER: *A Large Midwestern Paper Manufacturer.*

DATA: To improve the finished surface of certain types and grades of paper, this manufacturer decided to insert a new sizing and smoothing section between existing sections of one of their paper machines. *Requirements: 1.* New section drive rpm must remain in same preset speed ratio with first dryer section roll regardless of over-all machine speed; allow precise, minutely controlled variation to increase or decrease wet sheet tension; hold constant speed within 6% regardless of increase or decrease of section roll pressures. *2.* Section drive to be inoperative at will without use of clutches . . . machine to operate with, or without the new section for dual purpose processing. *3.* Drive must be smooth, positive . . . without lag, shocks, or surges. *4.* Drive must fit within extremely limited, available space, and be direct-connected to new section sizing roll. *5.* Complete, individual control from a convenient, remote, push button station. *6.* Dependability, with a minimum of installation, or maintenance "downtime."

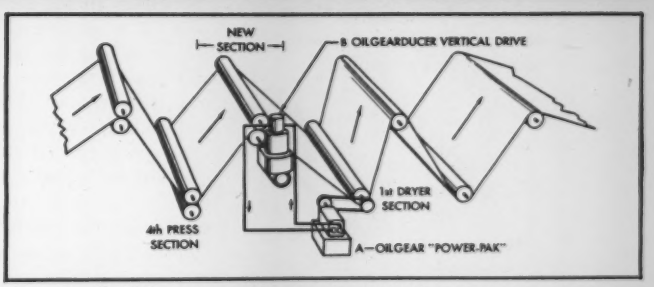
Note: A mechanical drive was considered, but space and control requirements would involve costly, major rebuilding of the entire machine.



SOLUTION: Oilgear *Application-Engineers*, working in cooperation with company engineers, analyzed the speed, torque, control, and space limitations of this installation; and recommended an Oilgear "*Any-Speed*" drive consisting of a separate, heavy-duty, Oilgear pump and motor for the following reasons. *1.* An Oilgear Type "DE," Variable Displacement Pump with Electric Remote Control and Reservoir fitted into the very limited space available, and could easily be driven from the first dryer roll. *2.* A standard *Oilgearducer*—an Oilgear Constant Displacement Fluid Power Motor with integral right-angle gear reducer—could be direct-connected to the new section sizing roll. *3.* A simple pushbutton station for controlling this new section could be conveniently mounted on the opposite side of the paper machine. *Actual operation has proved that all initial requirements were either met or exceeded.*

Being a positive displacement drive, the direct-connected sizing roll rpm remains in the same speed ratio with the first dryer roll regardless of over-all machine speed. Original constant speed requirement—within 6%—is exceeded in actual operation . . . speed remains stable within 0.5% max. variation under full min. to max. load change. Two remote control station pushbuttons command the electric pilot control motor to increase or decrease pump displacement, changing the hydraulic motor speed and the section to machine ratio . . . precisely varying tension on the wet sheet. Section can be independently started and stopped from this station while the paper machine is running. Exact drive load and temperature are indicated. *In over four years of continuous, high-speed service, there has been no reported maintenance on this drive.*

This paper manufacturer has also Oilgear-equipped a laminator winder drive; the center winder on a super-calender stack; the unwind and rewind drives on another supercalender; five "wet-end" drives of another paper machine;



Oilgear Variable Displacement Pump (A) is driven from the first dryer section to keep the new sizing and smoothing press section speed in direct relation to the dryer section speed. Actual installation is shown in photo above, left. The small, geared-head pump control motor which changes pump stroke can be seen to the right of the pump. Controlled Fluid Power from the pump drives vertically mounted Oilgearducer (B), direct-connected to the sizing roll of the new section . . . as shown in photo above.

plus other applications in the mill and powerhouse. This user, like many others in all phases of all industry, knows that *for the lowest cost per year—it's Oilgear!* Additional drive application data is available—Bulletins 10600, 10051-G, and "News" 3, 5, 8—on request, without obligation.

For similar practical solutions to YOUR rotary or linear drive and control problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

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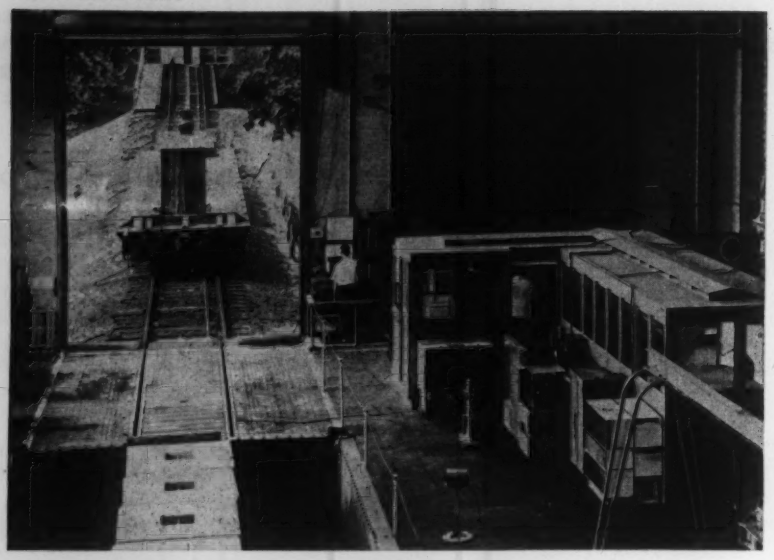


Hump Track Proves Packaging Design

Railroad cars colliding at controlled speeds provide clues to packaging needs of various items during shipment. It's done at one of the newest testing facilities of the Army Engineer's R & D Labs, Fort Belvoir, Va. A full-scale hump track gives packaging engineers a complete record of the effects of bumping, switching, and other conditions. An instrumented box-car, flat car, and gondola—loaded as "guinea pigs" for the studies—are pulled by an electric winch up a 66-ft long, 12 per cent grade. Cars can be tripped at any desired point. At the foot of the grade they roll along 100 ft of track on an unbanked curve and enter a final 158-ft level stretch within the lab for collision and switching studies. Computers and photocells determine velocities, accelerations, and stresses.

Space Satellite's Color May Depend on Temperature

Los Angeles—Chameleon-like space satellites may soon change color for protection—not to blend with their background, but rather to regulate their internal temperature.

Heat-sensitive coatings developed by Rudolf X. Meyer, Space Technology Laboratories Inc., change colors to control infrared absorption and reflection rates of coated surfaces. An application of the coating to a satellite's shell would keep temperature inside the vehicle uniform. As internal temperature increased, the skin would become lighter in color, reflecting more heat into space. Should internal temperature drop, the skin would become darker, absorbing more radiation.

According to Meyer, the coating can be either a paint-like substance or a plastic applied in several layers. About 35 substances have the color-changing characteristics at required temperature levels. One coating changes from red to yellow with increasing temperature. In a polymer, the reversible transition from sol to gel state occurs as temperature increases. In the gel state, the polymer is a good radiation reflector, while in the sol state it is a good radiation absorber.

Importance of protecting satellite payloads from temperature extremes was demonstrated during the flight of Pioneer I. For that experiment, a fixed temperature control paint pattern was applied according to the calculated conditions under which instruments had to operate. As a result, when the vehicle went slightly off course and temperature conditions changed, no adjustment was possible and instrumentation failed. Had the new coating been available at that time, Pioneer I might still be in orbit, giving vital data today.

Although such coatings have been used in the past as temperature indicators, there is little history of their use as heat-control devices.

Topics

Merciful missile is designed to fight fires. The Firefly would be capable of reaching a fire 5 miles away in less than a minute, hover over it helicopter-like, and spray the flame with a ton or more of extinguishing fluid. Solar Aircraft Co., developer of the recoverable Firefly, says it would be particularly valuable for use in and around airports. Cost is expected to be less than that of a fully equipped airport fire truck.

• • •

The better to see you: Two-tone cars are easier to spot on the highway—and therefore safer—than single-color ones. Results of a study made by the Pennsylvania Chapter of Vision Conservation Institute Inc. show that two-tone cars are at least 20 per cent easier to see on modern highways, and at a speed of 60 mph, become visible to another motorist a half mile farther away than a solid-color vehicle.

• • •

Faster than any corn-picking machine now on the market, a new model tackles four rows of corn at a time, picking and shucking. Two rows at once were the limit of previous models. The International Harvester picker, which hooks to the front of a self-propelled combine, is in the testing stage and will be offered for sale next year.

• • •

Bovine boudoirs in at least one barn are furnished with modern materials instead of straw. The high cost of straw inspired an English farmer to develop a plastic foam mattress which fits a standard stall and cannot be pushed aside by the occupant. The plastic is easily cleaned and immune to water-rot. Bossy likes it too.

• • •

Majoring in math has grown in popularity. The 1958-59 academic year saw a 31 per cent increase over the previous year in number of college juniors enrolled as majors in mathematics. Increase in over-all junior-year enrollment was 3.8 per cent.

• • •

Simulated telephone service—and customer reaction to it—is provided by Sibyl, a computer-like machine and laboratory. Eliminating the expense of building special test equipment for one-time use, Sibyl consists of three co-ordinated sections: The "computer," which can be programmed to simulate functions of a proposed service; read-out equipment; and a series of operating consoles which allow human operators to perform functions which users believe are mechanical. The system is used by engineers and psychologists at Bell Laboratories Inc.

(Advertisement)

Design Data on Resilient Clutch Facings

4

EFFECT OF HIGH TEMPERATURES ON FRICTIONAL STABILITY

At today's higher ambient temperatures, frictional stability has become an increasingly important factor in selecting a clutch facing material.

With many facings, the coefficient of friction shows a marked change as the oil temperature builds up from "cold" to normal operating level at 200° F., 300° F., or even higher.

Engagement Characteristics

These changes in friction value can have a profound influence on engagement characteristics. Obviously, facings that engage smoothly at one coefficient of friction may engage too quickly at a higher value, producing an unsatisfactory engagement.

Conversely, a reduced coefficient of friction may cause the facings to slip excessively during engagement and, in turn, create even more heat.

New Resilient Facings

To overcome these problems, Armstrong development engineers have created a new group of resilient facings. The curves in Figure 1 show static coefficient of friction values for these facings at various ambient temperatures.

The top curve was produced by one of the first of these new materials. Note that friction value decreases only slightly as temperature is increased to 300° F. Beneath it, is the curve for a later development. With this second material, the static coefficient of friction remains essentially constant at all temperatures.

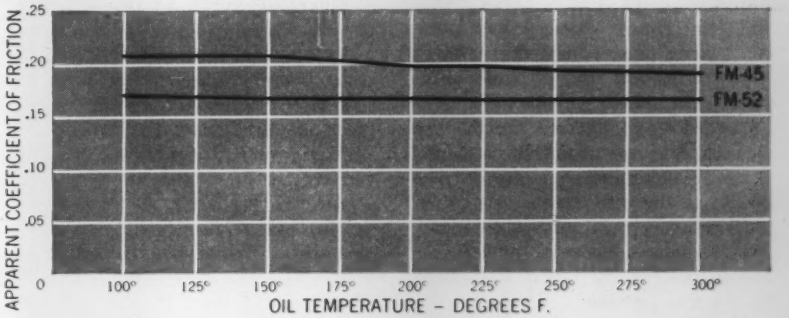


Figure 1. Results of dynamometer tests illustrate the frictional stability of two of Armstrong's new fiber friction materials at varying temperatures. A flat plain plate (6¼" I.D., 7½" O.D.), immersed in Type "A" transmission fluid, was engaged under a pressure of 150 psi. After break-in period of 300 cycles at 200° F., static coefficients of friction were determined at each temperature level.

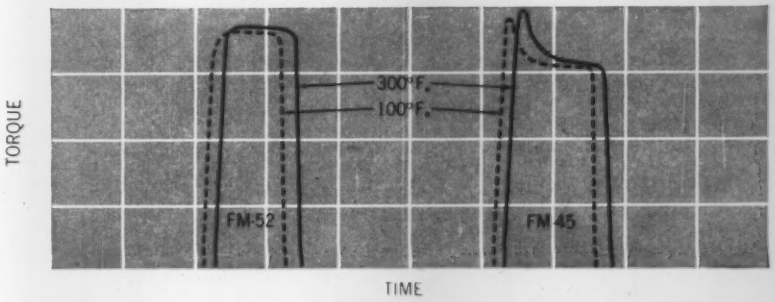


Figure 2. Torque curves recorded during the tests show that elevated temperatures (in spite of their effect on the transmission oil) have little effect on the engagement characteristics of either of the new Armstrong facings. Friction values are not necessarily representative of those that would be obtained in any specific transmission, or after prolonged cycling.

Figure 2 compares the torque curves for each material at 100° and 300° F. With high frictional stability, the engagement characteristics of these materials show little variance as temperature is increased by 200° F.

Research Technique

The data shown in Figures 1 and 2 were developed in tests on the Armstrong Wet Friction Dynamometer (left). In these tests, a large, rapidly rotating flywheel is brought to rest by the friction developed when a clutch faced with the test material is closed.

The characteristics of each engagement of the clutch are graphically recorded, producing curves similar to those shown in Figure 2. Coefficients of friction, as in Figure 1, are then plotted from the torque curves.

. . . . . .

For assistance in solving a problem involving friction materials, send complete details of your application to Armstrong Cork Company, Industrial Division, 7207 Dean St., Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Nerve-Cell Studies Lead to New Static Component

Low-Level Grid Signal Modulates High-Amp Currents

NEW YORK—A new static-control component, designed for switching and modulating high-amperage ac circuits, has its origin in studies of the human nervous system. Like the neuron (a single nerve cell), the Ovitron unit changes from nonconducting to conducting states when triggered by a low-energy stimulus.

According to modern theory, the neuron is surrounded by a semipermeable membrane charged positively on the outside, negatively on the inside. Permeability of the membrane surface increases and it becomes conducting when stimulated by a nerve impulse.

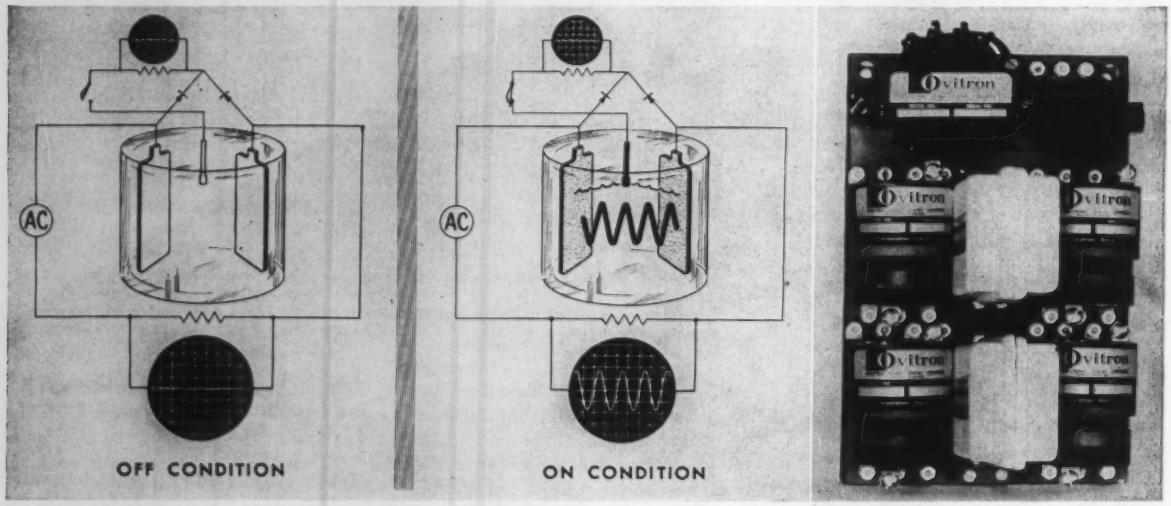
In Ovitron, two load-carrying electrodes immersed in an electrolyte are coated with oxide films that form semipermeable surfaces. Application of a small dc potential to a grid control element polarizes the load electrodes, switching surface films from nonconducting to conducting states. When the control signal is removed from the grid—or when a signal of opposite polarity is applied—conducting surfaces of the load-carrying electrodes revert to their original nonconducting states.

According to developers—Ovitron Corp., Detroit, Mich.—life expectancy of the unit is expressed in years of operation, rather than in X-millions of on-off cycles. Load electrodes and grid are said to be impervious and nonreactable to the electrolytic bath and show no dimensional variation, disintegration, or internal change with repeated operation. There is no depletion of the electrolyte, since small quantities of gases formed by the grid current are returned to solution by a catalyst.

Research and product development work to date has been largely devoted to commercial and industrial applications requiring control of current in the range from milliamperes to 15 amperes. Working laboratory models have been tested as circuit breakers, amplifiers, regulators, logic devices, and proximity switches.

Maximum voltage rating of present Ovitrons is 70 v ac per single cell; minimum rating is 3 v. Multiple-cell units can be supplied for higher ratings. Current ratings can be varied by increasing or decreasing size of the unit and surface areas of load-carrying electrodes.

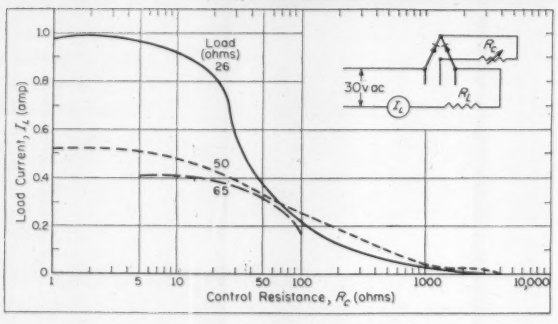
Ratio of control to load currents can be varied from 10:1 to 50:1, according to the demands of the application. Power gain is about 650, or 28 db. Developers of the unit say that speed of response is comparable to that of magnetic amplifiers, with higher speeds at lower gain ratios. During response tests, "break" time has been held between one half to three cycles of 60-cps input. Applied voltage has a slight effect on the break characteristic; varying current within rating has no measurable influence.



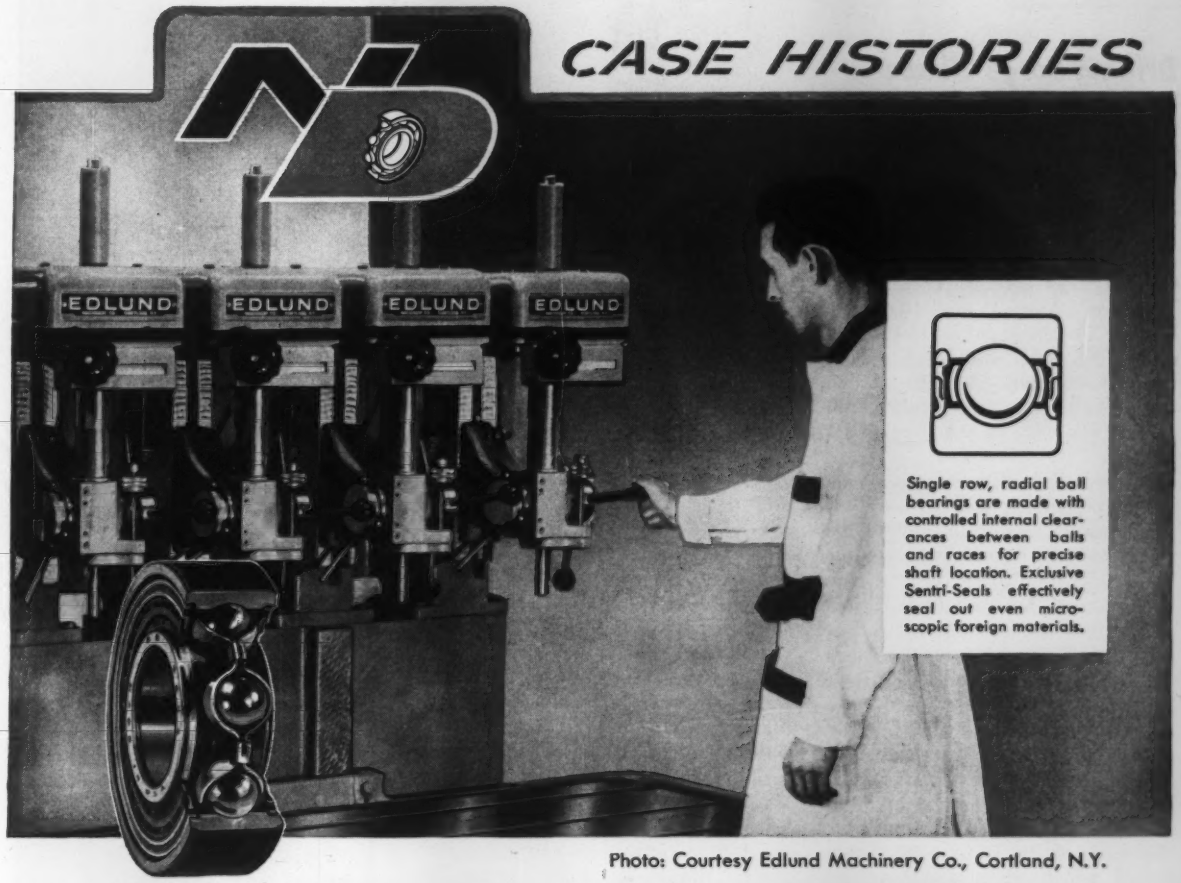
Self-energized excitation (above, left) can be accomplished with twin diodes which block ac from the grid-control circuit. Diodes pass pulsating dc of proper polarity to grid and load-connected electrodes. Substituting a variable resistor for the switch shown in the grid circuit allows load-circuit current to be modulated in proportion to grid signal.

Load currents controlled by the static-control unit range from milliamperes to 15 amperes. Combinations of normally open or normally closed switches are obtainable. Photo (above, right) shows four-pole relay.

Varying grid-circuit resistance gives load-current vs. control-resistance characteristic curves plotted at right.



CASE HISTORIES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Single row, radial ball bearings are made with controlled internal clearances between balls and races for precise shaft location. Exclusive Sentri-Seals effectively seal out even microscopic foreign materials.

Photo: Courtesy Edlund Machinery Co., Cortland, N.Y.

Ball Bearing Design Adds Efficiency... Cuts Relube Maintenance In Drilling Machine

CUSTOMER PROBLEM:

Tool manufacturer requires minimum maintenance ball bearing design for new high-speed multiple drilling machine.

SOLUTION:

N/D Sales Engineer, cooperating with company engineers, recommended New Departure ball bearings with exclusive Sentri-Seals in place of conventional open bearings. These ball bearings, sealed and lubricated for life, virtually eliminated bearing relubrication maintenance. In addition, these sealed bearings accounted for a savings in parts and assembly time by eliminating costly lubrication plumbing and fittings. What's more, the application has proved so successful, the customer has had other types of drilling machines redesigned to use New Departures.

If you're working on new machine designs, why not call on New Departure? There's probably an N/D *production* ball bearing that will help you, and, at a lower cost! For more information write Department Q-7.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

Drilling Barge Climbs Legs in Bootstrap Action

Hydraulic Rams Help Mr. Louie Shinney Up 211-ft Caissons

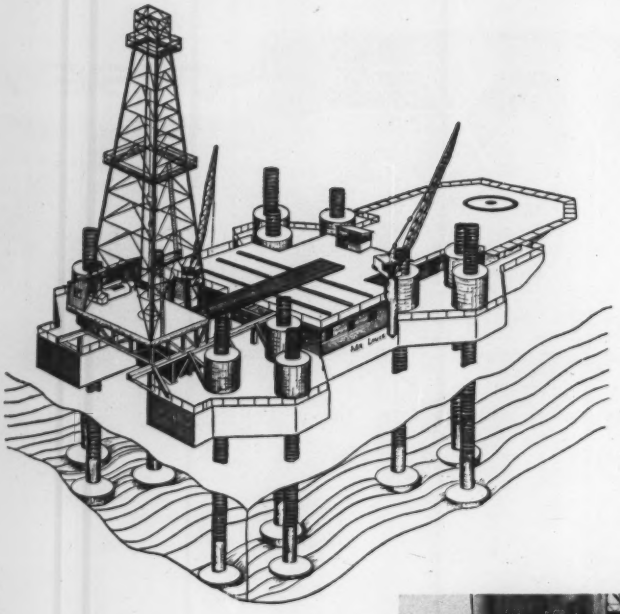
RICH oil beds are prospected from a new 40,000-ton drilling barge developed by Universal Drilling Co. It uses a jacking system designed by Oilgear Co., Milwaukee, to lift itself out of the water and shinney 60 ft up its twelve pole-like legs. When in position, the rig (called Mr. Louie) can drill in water up to 120 ft deep.

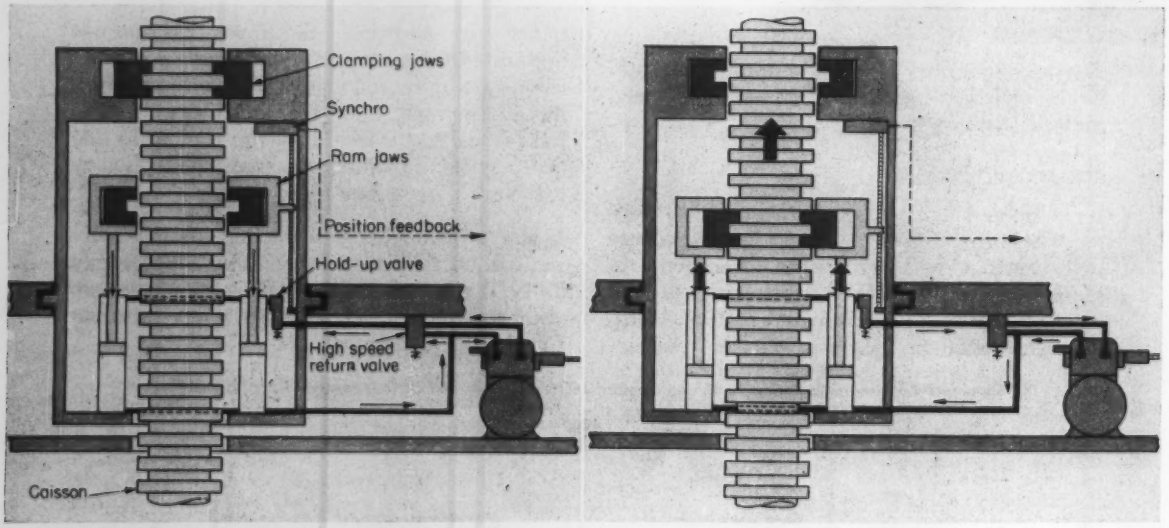
Individual hydraulic pumps and controls on each leg operate independently or in unison. Pole climbing is done in unison after the footpads have been adjusted to the uneven bottom by individual control.

Eight of the caisson jack frames go through the body of the single-hull barge, and four additional units are located in outboard extensions for added stability. Oilgear's 12 two-directional pumps are controlled by a pilot hydraulic system triggered electronically from a central control station. Sensing devices and feedbacks supply a display board which gives operating personnel a picture of the state of the barge and caissons at all times.

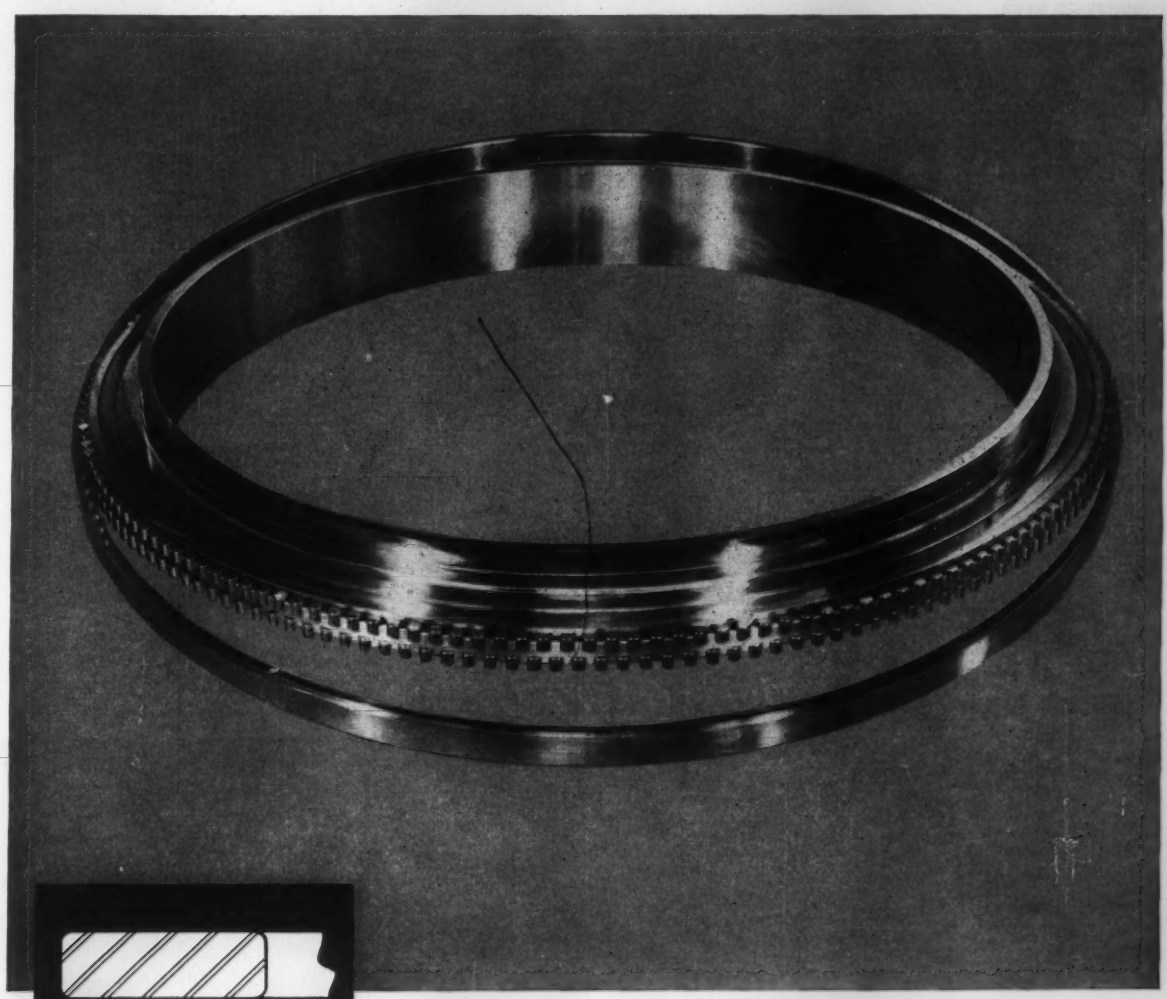
An automatic sensor detects a deck tilt as small as 7 minutes and adjusts output of jacks to correct the condition. Half a degree of tilt causes unison jacking to stop until the situation is corrected. Unison jacking is also used to "meter down" the heavier-than-water legs. Clamp rings spaced 18 in. on center provide a firm clamping surface for jacking jaws.

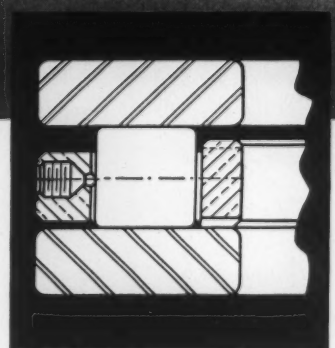
Up to nine holes can be drilled, after the barge is in position, by moving the drilling tower along a track toward the rear of the barge. It is kept amidships until the barge is stabilized.





Two sets of jaws alternately clamp and release the leg as the barge hoists itself out of the water. Moving jaws attached to hydraulic pistons have a 54-in. stroke. Feedbacks give centrally located operator information on depth of caisson, jacking speed, load on each leg, etc. Return valve allows quick piston return with metered pump bypass.





Running mate of the Torrington Radial Roller Bearing pictured is this Torrington Cylindrical Roller Thrust Bearing 52 in. OD, assembled face runout 0.0004 in., capacity 222,000 pounds at 100 rpm.

A picture of precision... 57.500 inches in diameter!

Here is an ultra-precision Torrington Radial Roller Bearing, custom-built for Wickes Machine Tool Division's 48" Center Drive Profile Lathe.

Almost five feet (57.500 in.) in diameter, it has a total inner race runout of only 0.0005 in. Its 344 rollers are held uniform in diameter within 0.00005 in. Radial capacity is 318,000 lb. at 100 rpm. Rollers are staggered in a one-piece, fully machined bronze cage for precise guidance and cool running. The bearing bore is tapered one inch per foot, and carefully mated to the spindle which was also ground by Torrington.

Such precision is possible only through specialized equipment and highly practiced skills—the same that lie behind the quality of every Torrington bearing, standard or special. Not every bearing order calls for such precision—but each is given the extra measure of care that makes Torrington quality a byword in industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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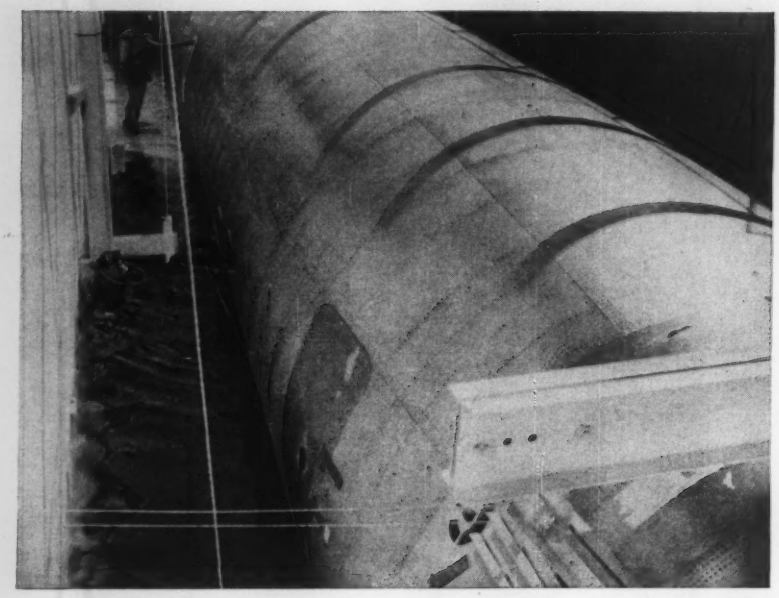
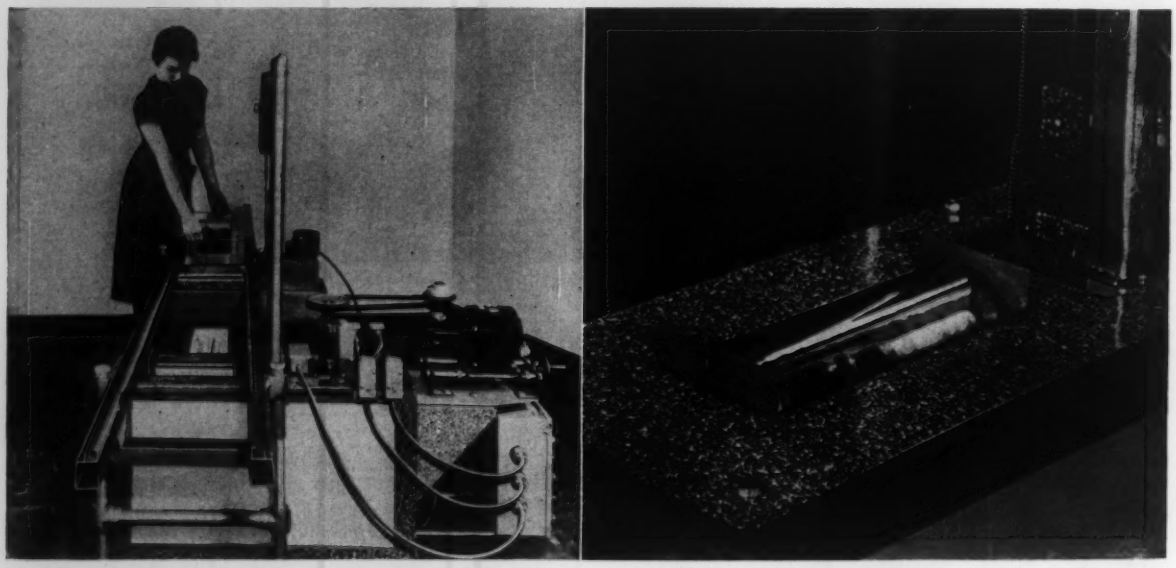
Convair-880 Pressure Tested To Simulate 20 Years of Flight

Submerging Convair's 880 jet transport in 395,000 gallons of water is the first step in the hydrostatic pressure test program adopted by Convair Div., General Dynamics Corp., San Diego. The program, designed to prove the reliability of the 615-mph passenger plane, will last six months, and will simulate 20 years of operation under more severe conditions than those imposed by commercial service. The sealed cabin will be pumped up to simulate cabin pressures of up to 6000 ft. Whiffletrees linked to metal straps and operated by hydraulic rams will produce stresses encountered during landing. While the plane is underwater, more than 800 flights will be simulated before deliveries are made to airlines early next year.



Standing Wave of Molten Metal Solders Circuit Boards



Standing waves of solder and flux replace the conventional dip tank in a fast new method of soldering printed-circuit boards. Conveyor track, left, passes the boards over a flux wave, then over an infrared heating unit to drive off the flux solvent, and finally over the solder wave, right. Preheating of boards prior to soldering reduces thermal shock and resultant warpage. Wave height and temperature can be kept within ±0.03 in. and ±1 F, respectively.

NEW YORK—Printed circuit boards are washed by a standing wave of solder in a new process which is said to produce soldered connections having higher shear strengths and greater reliability than those obtained in dipping or other conventional methods.

Heart of the new system, developed by Electrovert Inc., New York, is a unique machine that forces solder up underneath the circuit-board assembly as it passes over on a flat conveyor. An impeller pump forces the molten metal through an elongated nozzle so that it forms a standing laminar wave. Flux gases escape easily from the smooth, non-turbulent solder wave and the gentle washing action of the constantly moving metal prevents trapping of gases or air at joints. The constant flow of fresh metal also insures uniform soldering temperatures. No significant heat loss occurs during the process as it does in conventional soldering methods, where the

circuit board contacts a static pool of metal.

Joint strength, which depends largely on height of the solder fillet, is enhanced considerably, since higher fillets are possible. These result from the higher temperatures which can be used without heat damage to the boards; the better "wetting" of surfaces to be soldered; the capillary and filling action developed by the moving solder wave; and the elimination of dross or oxide contamination.

Engineering Enrollment May Drop Again This Fall

Misguidance of Students Cited as Contributing Factor

NEW YORK—When the new crop of students heads for college in September, it is likely that fewer will begin working toward engineering degrees than last year. This is significant because 1958 saw a more than 11 per cent drop in engineering enrollment—the first decline in eight years.

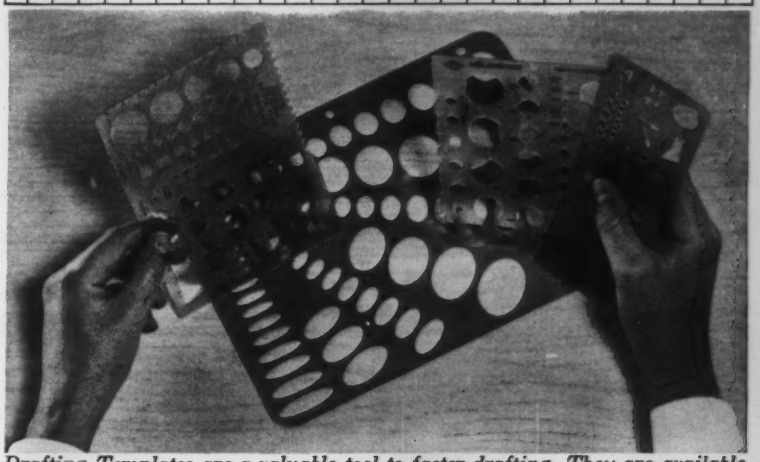
Another, more serious problem reported by deans and presidents of engineering schools is the rate of attrition of undergraduate engineering students. The trend prevails in 35 per cent of the 70,000 schools reporting in a survey made by the Engineering Manpower Commission of Engineers Joint Council and the Scientific Manpower Commission.

Main reason for students' bypassing careers in engineering is laid to faulty guidance by school counselors, parents, and other students. Their advice, it is felt, was based on reported reduction of engineering personnel during the recession and represented a rather gloomy appraisal of career possibilities in this field.

Other factors standing in the way of engineering enrollment are concern about the difficulty of the course of study and increased interest on the part of potential engineers in other scientific fields.

Placement posed no problems for last year's graduates. In June, 1959, 63.3 per cent had accepted jobs, compared to 59.2 per cent in 1958, and only 6.7 per cent had no plans or employment offers, compared to 10.8 per cent in 1958.

DRAFTING TRENDS



Drafting Templates are a valuable tool to faster drafting. They are available in an almost endless variety.

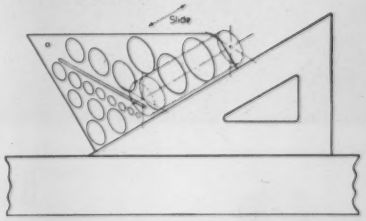
Specialized drafting templates speed drawing time

Always a handy tool, drafting templates are becoming increasingly in use to simplify everyday drawing techniques. Now vinyl plastics are used in the manufacture of the majority of templates. But the thickness, color and finish vary in almost endless profusion. Glare-saving colors, such as green and amber, are usual, both in clear and matte finishes. However, the white and clear plastics still are popular. The thicknesses vary with the different types of available templates from .020 gauge through .070 gauge.

Specialized template applications

A list showing the growing application for templates includes templates for: Electronic Symbols, Electrical Wiring, Landscaping, Screw Heads, House Plans, Nuts and Bolts, Screw Threads, Tooling, Windows, Plumbing, Mathematical Symbols, Map Planning, and many "all-purpose" templates for circles, ellipses, triangles, and other shapes.

Isometric ellipse template is a big timesaver



An isometric ellipse template may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.

A selection of 52 popular templates is illustrated and described in a special six page brochure, "Drafting Templates" recently published by Frederick Post Company. *For your copy, write Frederick Post Company, 3652 N. Avondale Ave., Chicago, Illinois.*

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Circle 411 on Page 19

STANSCREW

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in fastener service

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This symbol personifies a trained staff of fastener specialists. Their technical assistance can often help you reduce fastener and assembly costs.

It means extra quick deliveries from complete inventories maintained at three conveniently located plants . . . over 5,000 different types and sizes to assure a broad selection for the great majority of your requirements . . . and, above all else, fasteners of consistently high quality.

Although it first appeared in 1958, the Stanscrew trademark represents a wealth of fastener experience. For it combines the technical skills and specialized facilities of three major manufacturing divisions of Standard Screw Company, each an honored name for more than 80 years. They are:

THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
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THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

For fasteners, specify Stanscrew. For other needs of home and industry, Standard Screw divisions also produce:

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Roosa Master fuel injection pumps • Chicago tappets

Each division also provides a complete design and manufacturing service for cold headed and screw machine products.

STANDARD SCREW COMPANY
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Index to New Parts & Helpful Literature

BY ITEM NUMBERS

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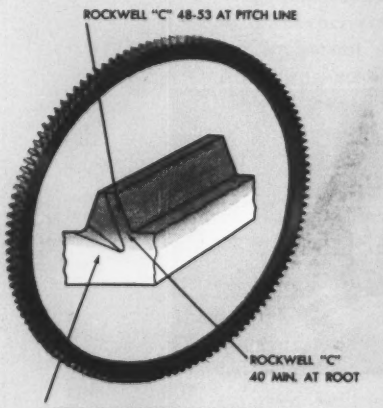
To the Outboard Motor Industry

on its

GOLDEN JUBILEE

At the end of its first half century the outdoor motor industry can regard its "family of fans" with pride—all 35,000,000 of them. Today almost 25% of this nation's population find fun, recreation, even employment in outboard powered craft.


ROCKWELL "C" 48-53 AT PITCH LINE
ROCKWELL "C" 40 MIN. AT ROOT
DUCTILE BODY ROCKWELL "C" 10-20
SHADED AREA IS HARDENED WORKING SURFACE

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GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 413 on Page 19

FAA wants airliners that fit

Designers of commercial jet aircraft may have a new problem on their hands in the near future. FAA chief Elwood F. Quesada is taking a firm stand against lengthening runways at the nation's many major airports every time the airlines buy a new round of bigger and faster aircraft. From all indications, planemakers will have to design future models to operate from existing facilities. Four-engine piston transports now in service need 5000-6000 ft of runway, versus about 9000 ft for the first generation of subsonic jets. If military's Mach-2 jets are any benchmark, supersonic jetliners would need considerably more than 9000 ft.

engineers may double as part-time teachers

Full-time engineers may find themselves taking on part-time teaching jobs if industry favors a new scheme to beat the shortage. Thomas Meloy, president, Melpar Inc., suggests industry could supply instructors to colleges not having complete engineering courses. Programs of in-plant training for academic credit could also be worked out. Basing the plan on his company's experience, Meloy sees it solving one of industry's most urgent problems—the predicted shortage of 20,000 engineers within five years.

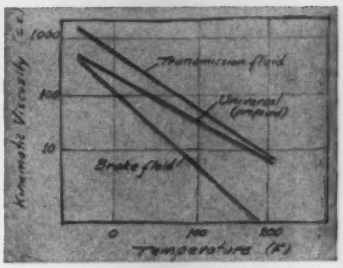
aluminum auto engines get simplified block

Development of a feasible die-cast aluminum V-8 engine block marks an important step toward economical production of aluminum auto engines, and solves major diecasting problems. The design eliminates blind passages, undercuts, and projections, but incorporates oil and water passages in the casting, thereby avoiding expensive machining. Doehler-Jarvis Div., National Lead Co., claims the approach is applicable to any V-8 engine.

new silicones blend to desired hardness

Two new general-purpose silicones offer wide latitude to designers of tubing, gaskets, seals, and diaphragms. Silastic 52 (50-durometer) and Silastic 82 (80-durometer), can be blended to any intermediate hardness. Developed by Dow Corning Corp., they can be easily processed, have high green strength, and high heat stability. They can be released from mill rolls without the use of scraper blades and can be readily produced in unsupported sheets without ripping or tearing. Even after several days exposure to 600 F, they retain good flexibility. Fabricator's inventory of only two stocks should allow substantial savings. Both are available either catalyzed or uncatalyzed.

SAE tailors universal fluid for central hydraulics

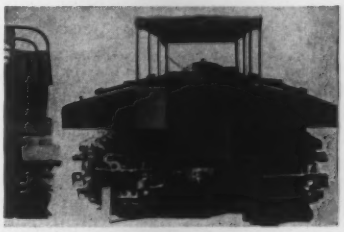


Performance requirements for a new "universal" hydraulic fluid have been tentatively worked out by SAE committees. Called the key to central hydraulic systems for passenger cars, the single fluid will power not only brakes and steering (now supplied by separate fluids), but also a range of new fluid-power options from windshield wipers to air conditioners. SAE investigators (Subcommittee H) found braking and steering were most demanding on the universal fluid: Brake oil must be fast acting at −40 F; power-steering oil must stand up under high temperatures generated by continuous pumping. To satisfy the extremes, viscosity-temperature characteristics of the universal fluid were tailored to bridge the gap between current automatic-transmission oil (type A used in power steering) and brake fluid. SAE will soon issue a recommended-practice report detailing full specifications for the central-system fluid. Results of field tests may permit relaxation of some universal-fluid requirements.

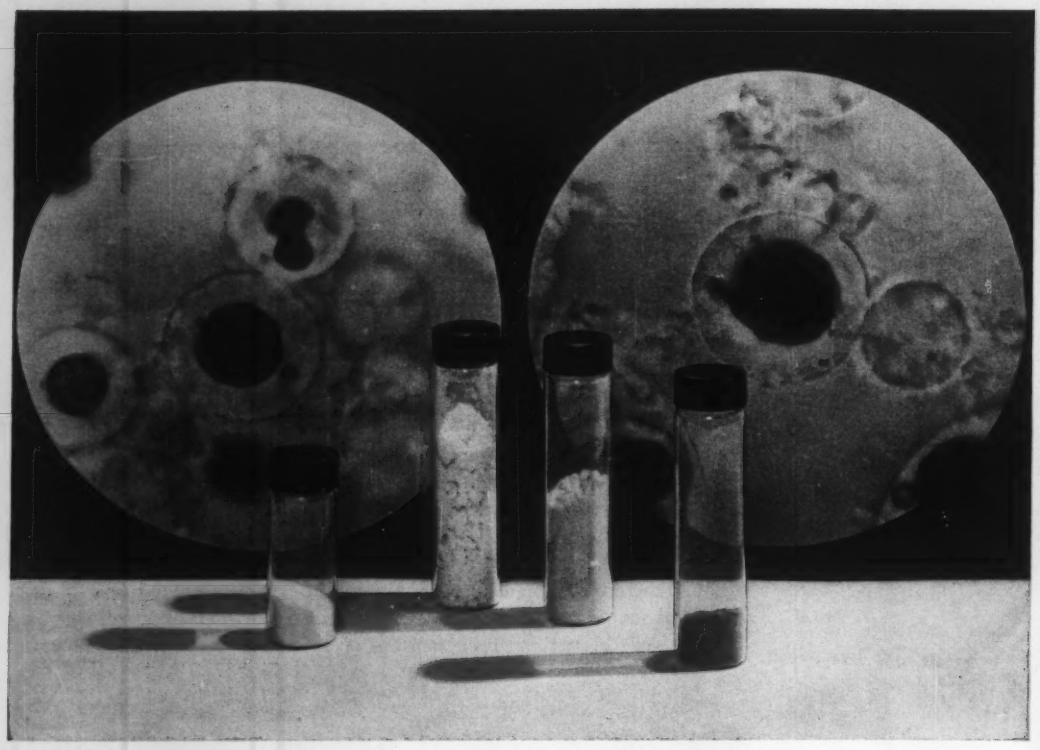
fired-up research effort aims at new oil-burning equipment

Oil-fired air conditioners and incinerators are two of many design objectives in a new research program aimed at updating the general state-of-the-art in oil-burner equipment. Improvement of residential heating and water-heating equipment are two other primary targets of the program, sponsored by American Petroleum Institute. According to API, manufacturers of oil-burning equipment are not fast enough on the draw in exploiting new concepts turned up in recent combustion research, and they also lag in developing new products. These facts, plus the unfavorable initial cost of oil-burning equipment (tanks and installation) put oil at an unnecessary disadvantage, says API.

down-to-earth research pays off for tracked-vehicle designers



Track-force mechanics in deformable soils is a fertile new subject gaining wide interest among designers of track-mounted vehicles. The subject gained brief notoriety in World War II: Tank tracks designed for desert travel performed miserably in Europe's mud. Present state of the art shows that it is possible to predict fairly accurately the resistance to forward motion and the total tractive effort of a track mounted on a vehicle moving straight ahead on level, nondeformable soil. Equations relating to soil deformation and to soil-vehicle relationship have also been proposed. First results: The space-link track, above right. Pioneering work in the field is being done by Army's Land Locomotion Lab., Ordnance-Tank Automotive Command, and by Cornell and Michigan State Universities.



Photomicrographs blown up on screen behind vials of sample powders show remarkably regular form of NCR's capsules.

MICROSCOPIC drops of liquid—wrapped in cell-like gelatin shells—are now offering industry a new way to handle fluids like solids. Resembling one-cell micro-organisms, such capsules respond to light, perform memory functions, enclose toxic chemicals, or form new sophisticated dry-wet lubricants.

The encapsulation process, developed by National Cash Register Co., Dayton, Ohio, can encase droplets as small as one micron in a thin shell of gelatin or other suitable film-forming material. First commercial use was on carbonless duplicating paper for business forms. This paper employs coatings of two different chemical compounds—one a colorless dye enclosed in the tiny capsules and the other an activated clay which accepts electrons. When the paper coated with capsules is struck by typeface or subjected to the pressure of a pencil point, capsules rupture at the point of contact. The colorless dye is freed and electrons are transferred to the electron acceptor, whereupon the colorless dye assumes a colored (blue) form. As a result, perfect copies of what is written or typed on the first sheet of the business form are created on subsequent sheets of the form.

Another dramatic application under development at NCR could result in variable-density sun glasses. Cells, encapsulating a photo-sensitive material that darkens under strong light, are coated on the goggle glass. Response is fast enough to cut off blinding flashes from atomic blasts, yet the coating clears quickly to give the wearer a normal view in subdued light.

Pilot's face mask, coated with capsules, blocks bright flashes of light, but quickly returns to clear condition under normal or subdued light. Photosensitive material in the capsules does the job.

dry liquids . . .

that handle like flour are actually tiny gelatin capsules encasing oils, dyes, and highly reactive chemicals. Here's how industry's putting them to work.

Mixing the Untouchables

The capsules can be used in many industrial applications which involve mixing or reactive problems. In effect, encapsulation permits reactive compounds to be intimately mixed without premature reaction. When the capsules are ruptured—through heat or pressure, for instance—the desired reaction takes place. Instead of reactive materials being brought together just prior to use, encapsulated materials can be premixed without danger. Proportioning and control problems are correspondingly simplified. This possibility may give more flexibility to the design of future proportioning machines.

Highly reactive components of rocket fuel have been encapsulated to allow accurate and thorough mixing in specified ratios. The capsules help protect handlers from poisonous fuels, and reservoir walls from contact with corrosive fuel elements. If research is successful, the encapsulated fuel should make possible simpler rocket-engine design incorporating desirable features of both solid and liquid-fuel rockets.

Oil Dust for Dry Ways

New types of lubricants for special purposes or unusual conditions will result from the new process. NCR chemists have already encapsulated many different oily materials, producing powders which release their enclosed lubricants under pressure or as the result of rubbing. Coatings of encapsulated lubricants can be applied to various surfaces, with the lubricants being released as needed when the surfaces are subjected to friction.

In cases where a volatile or unstable lubricant must be protected over a long period of time, encapsulation of the lubricant protects it against deterioration until it is needed. Encapsulation can also solve incompatibility problems in the formation of special lubricants by keeping sensitive materials separated until friction or heat ruptures the capsules and allows the desired reaction to take place at the time lubrication is demanded. Research studies indicate little, if any, adverse lubricating effect from the presence of the capsule residue.

Plastics . . . Paints . . . Adhesives

The field of plastics will be affected by the tiny capsules. Some

current plastic fabrication involves the mixing of a resin and a catalyst; it can be simplified by premixing the materials in capsule form. They will remain "inert" until pressure or heat is applied. This single premixed component—which can be a liquid, solid or paste—can eliminate the need for pre-fabrication mixing and its attendant problems and extra costs.

Encapsulation aids in the formulation of special-purpose paints for extremely adverse conditions. Such paints frequently are based on reactive materials that combine shortly before their use. Through the encapsulation process, such materials can be combined at the factory. This procedure will offer substantial economies because it eliminates waste caused by deterioration and, at the same time, provides better quality control.

Another area for the application of encapsulated materials is in the preparation of adhesives. At the present time, most structural adhesives such as epoxies and phenolics are mixed with catalysts just prior to use. Encapsulation permits premixing these materials, with capsule rupture occurring at the time and place desired as the result of applying heat.

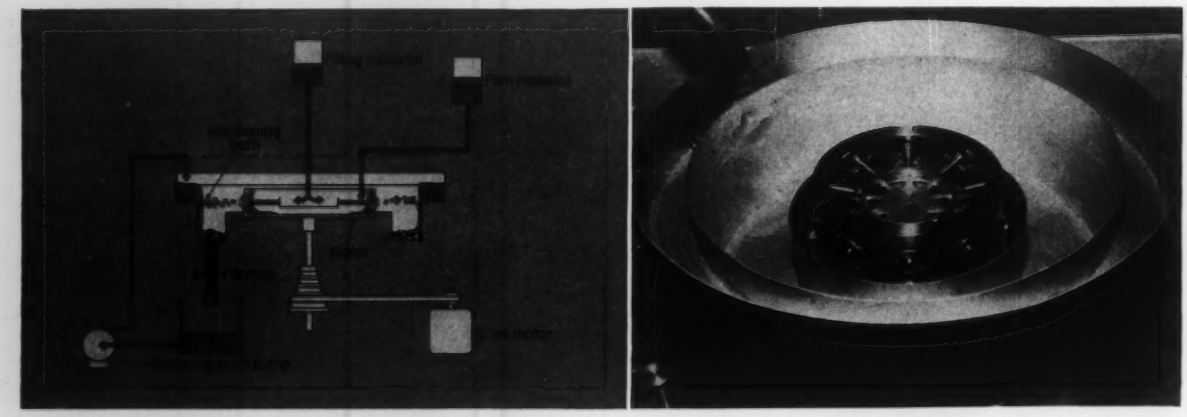
Pressure-sensitive adhesives also can employ the encapsulation principle. Tacky resins on tapes can be replaced with nontacky coatings of encapsulated material which become sticky only when pressure ruptures their protective capsular casings. Such a development eliminates protective interlayers on rolls of tape. In general, adhesives using two or more components can become, in effect, one-component systems.

Heat 'n Serve

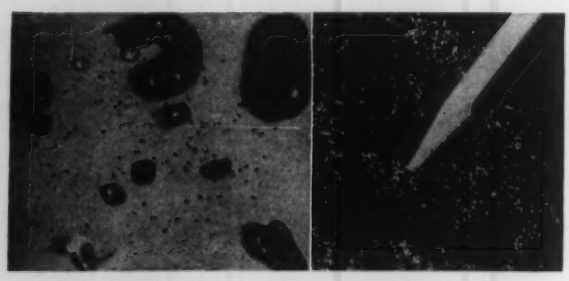
Encapsulating foods, perfumes, and medicines preserves freshness and inhibits deterioration of volatile substances by evaporation. A wet-dry towel coated with encapsulated detergent has been tried. After the person's hands are "washed," the detergent evaporates quickly and the towel can be used for drying.

NCR is currently conducting a vigorous research program to expand the applicability of the encapsulation process, and is also working with a number of other interested companies to develop more new products using encapsulated materials.

new whirls in capsule production



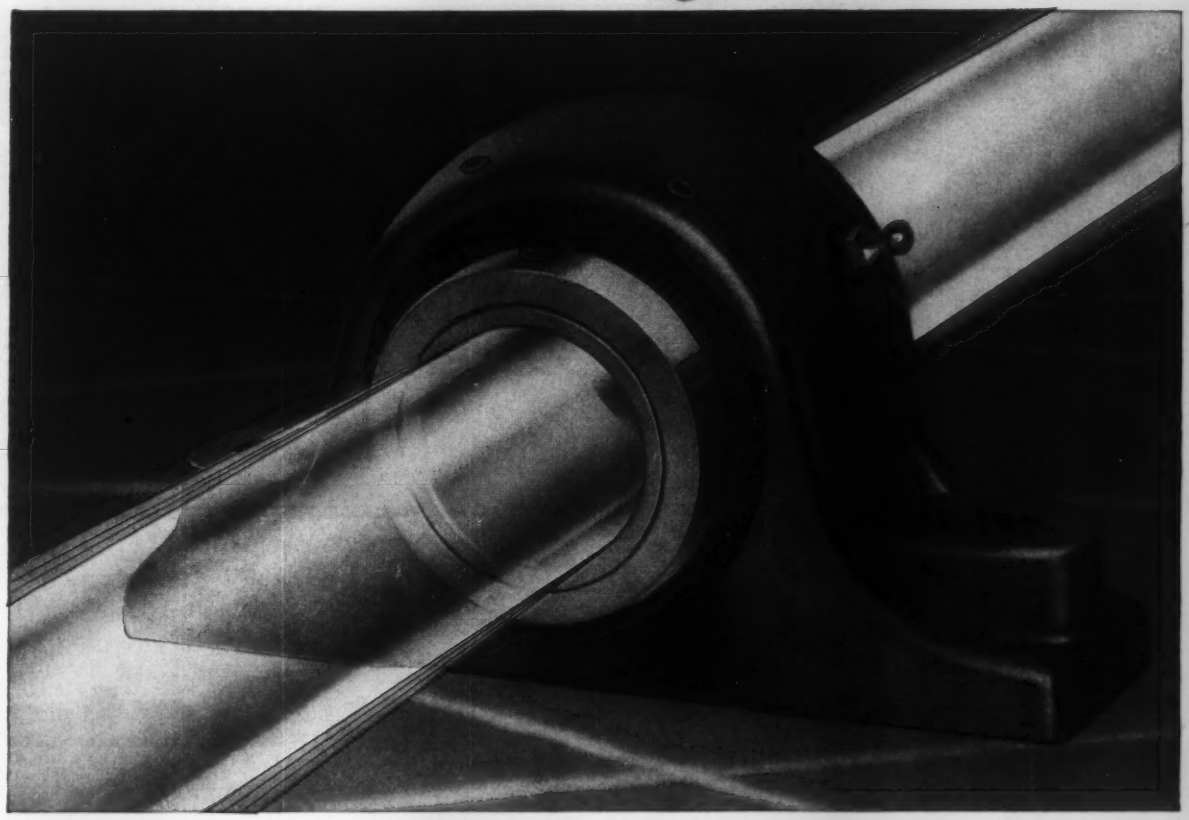
NCR is understandably quiet about exact details on the manufacture of its 1-mu capsules. A clue may be offered by Southwest Research Institute's technique. SwRI capsules, while thousands of times larger, are still tiny by most standards. Filler material feeds by gravity to a ten-nozzle rotor where it is whirled out through orifices covered with a thin film of the coating material. Droplets, coated with film, fly into a hardening bath that drips over the wall of an outer chamber. Finished capsules are recovered from the hardening bath by screening.



Typical SwRI capsules are about the size of a pencil point. Complicated forms—like a capsule-within-a-capsule—are possible, says SwRI. These may be used for catalysts and cocatylists, especially in toxic or pyrophoric systems. Low-melting-point alloys such as magnesium and aluminum have been considered for encapsulating materials—along with glass, paraffin, and gelatin. So far, 12 out of 200 tried materials have proved useful.

Free rolling . . . long lasting

because it's *Self-Aligning*



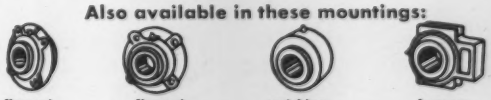
Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

For complete information on the Series 400 —and Link-Belt's complete line of ball and roller bearings—send for our Book 2550. It's available at any one of the 40 Link-Belt offices.

Look under BEARINGS in the yellow pages of your phone book.

Also available in these mountings:

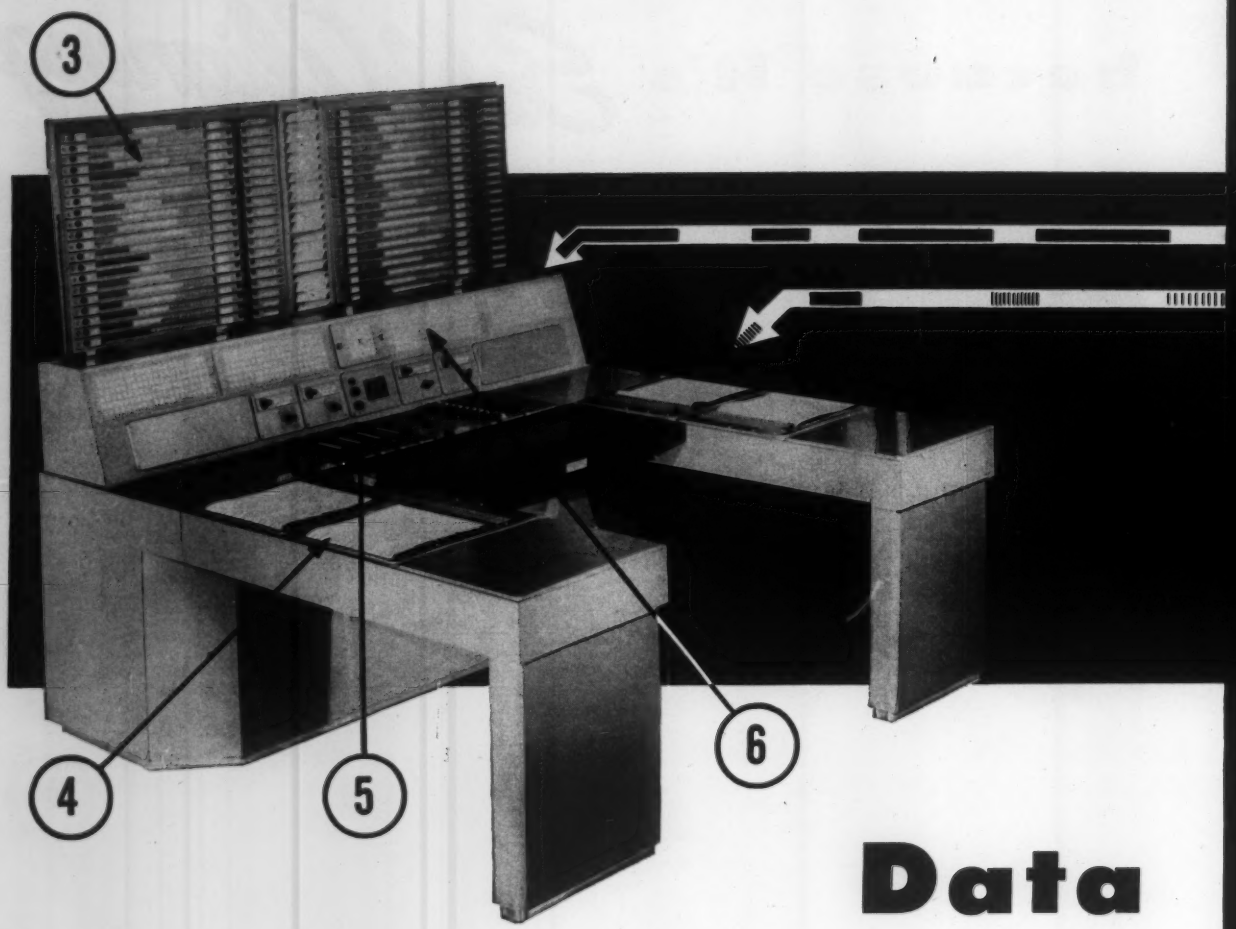


flanged blocks | flanged cartridge blocks | cartridge blocks | hanger blocks

LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,119-A



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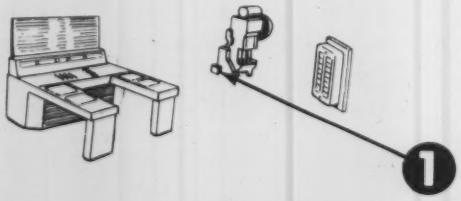
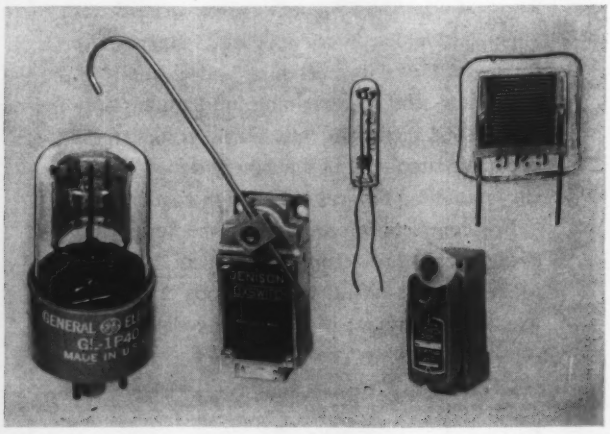
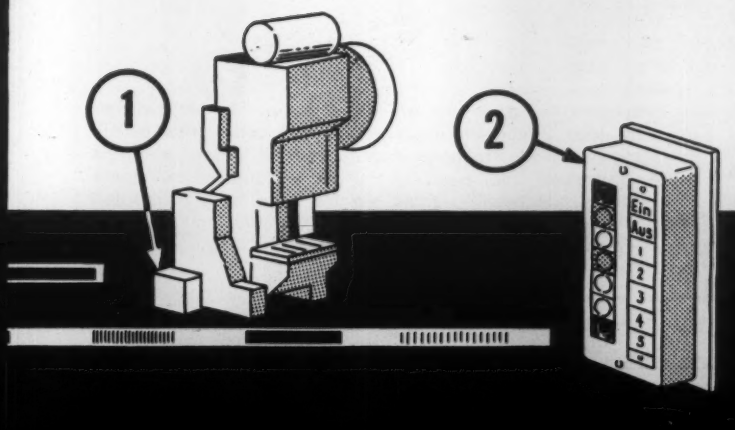


Impulses that actuate Productograph's charts, graphs, and counters, come from many types of transmitters, each tailored to the production machine monitored. Typical transmitters are cam-actuated limit-switches, direct or indirect connected gear transmitters, photo-electric cells, flow meters, voltage relays, and noise or vibration responding relays. Virtually any signal-generating device can be used.





Human-factors design demands close attention
when mountains of changing data
must be displayed and compared in a hurry.
Here's how it's done in Productograph . . .

Center
for automatic production control

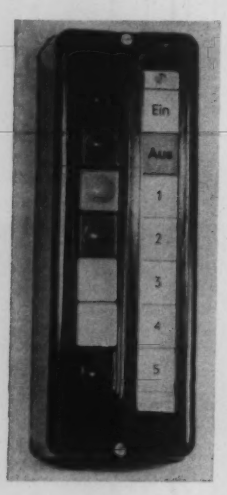
PAPER-AND-PENCIL methods of production control—even those built around manual data-display boards—may soon be outdated by new automatic equipment. One front-runner in the race to automatize production data keeping is Productograph, an instant-tally system that reports and correlates work output and downtime of every machine in the shop.

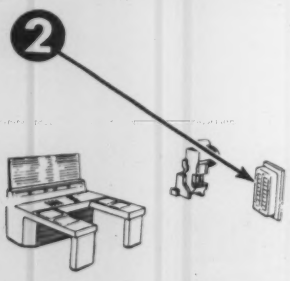
By advancing colored strips on animated bar charts, the system keeps a running visual comparison between production quantities and quotas. It also charts a permanent, coded record of machine output on waxed tape. Inpulses that actuate bar chart and recorder come from switches, photocells, and similar transmitters that monitor the work output of each machine.

Paralleling the production track on the waxed tape, a second track records work stoppage. Pushbutton switches permit machine operators to code the downtime track to show the reason for work stoppage—setting up, tool breakage, material shortage, etc. This up-to-the-minute picture of plant activity allows potential bottlenecks to be spotted before they become serious.

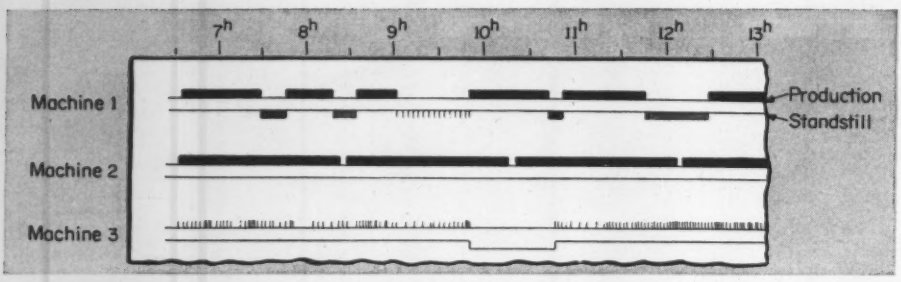
The system can be tailored to fit any size operation. Standard twenty-channel units can be added as needed. Flexibility is enhanced by auxiliary modules: High-speed recorders that permit remote time studies; coded trouble-lamp panels; counters to integrate total production and total downtime by reason; two-way communication systems; and magnetic-tape recorders.

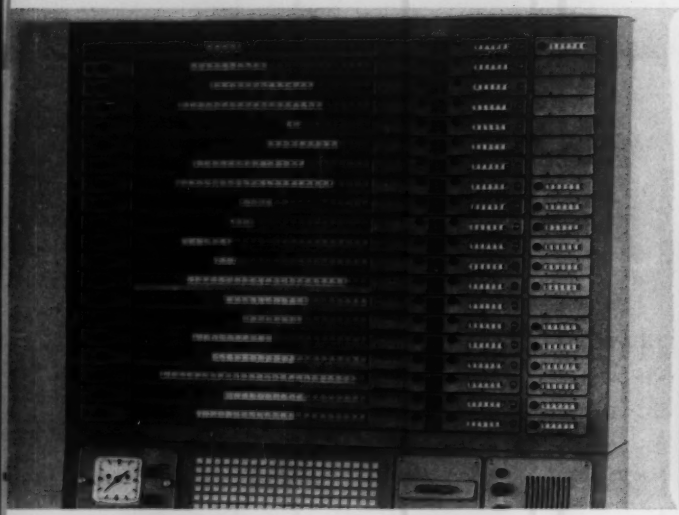
Designed and developed in Germany, Productograph is offered for manufacture in the U. S. by Rand Development Corp., Cleveland.

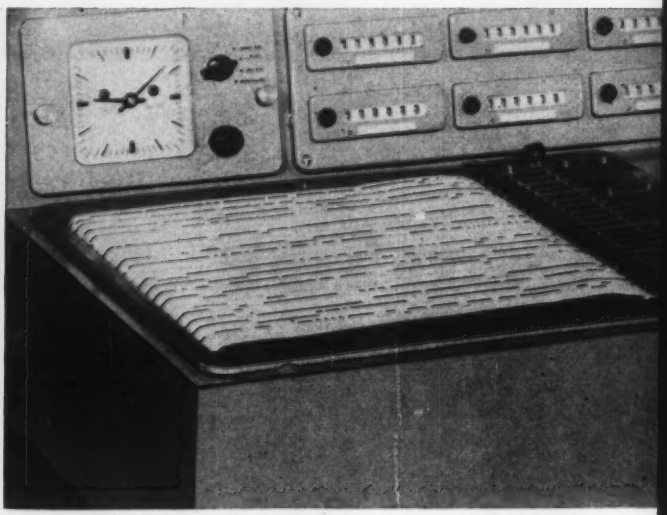


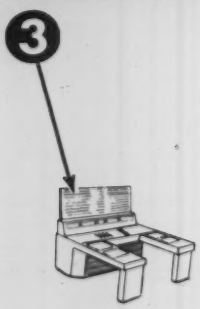


Reasons for downtime are coded by pushbutton switches at each production machine. Typical codes, five in all, identify work stoppage due to lack of orders, shortage of material, tool breakage, setting up, and miscellaneous causes. Standstill signals are fed to a trouble board—where they visually indicate what is happening—and to a recorder, where they are graphed as to length of downtime for future study.

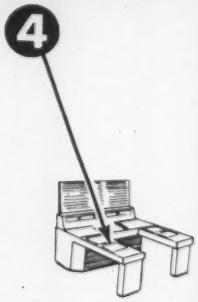




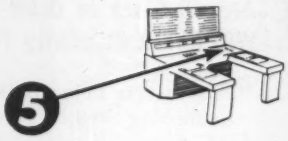




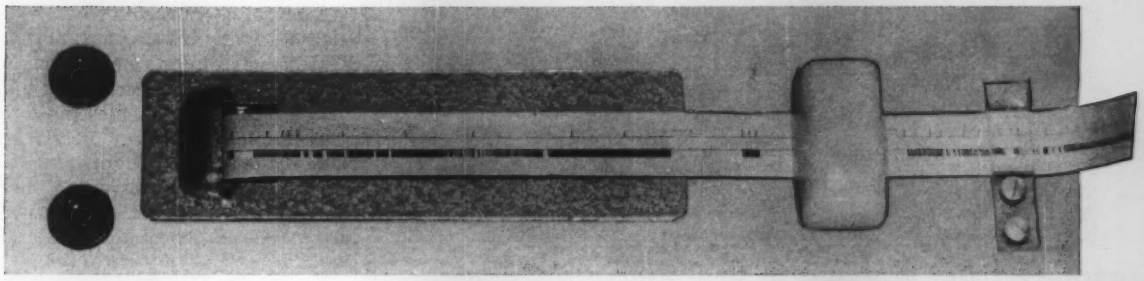
Automatic bar chart uses two colored film strips behind one scale to compare quota and current production of each machine. The quota-tape is preset manually. The production tape advances automatically, giving a quickly grasped comparison between production completed and production still required. Rate of tape advance is determined by a decade multiplier.

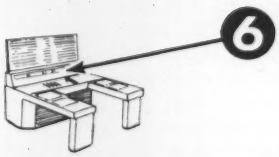


Production recorder graphs reports from machines on double tracks, without ink, on waxed paper. Chart speed is 30 mm per hr. On the top track, production of each machine is recorded. Decade-multipliers can be set to record every tenth, hundredth, or thousandth part produced. The lower track indicates both time and reasons for standstills.

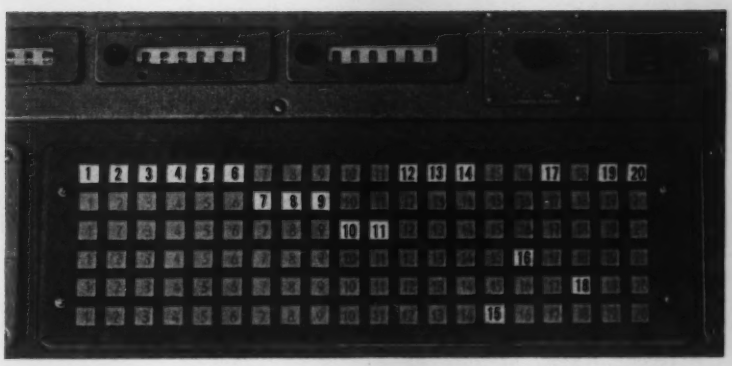


High-speed recorder (30 mm per min) can be switched to the input signal from any one machine to permit expanded-detail work analysis. Slow-motion recording of even the fastest operation makes possible remote time studies.





Trouble panel is designed to give an instantaneous picture of machine operations. Each of the twenty columns represent one machine. When a machine is operating, a light in the upper block of the appropriate column is on. When a machine is idle for one of the "trouble" or "production standstill" reasons, a light in another of the vertical blocks comes on.



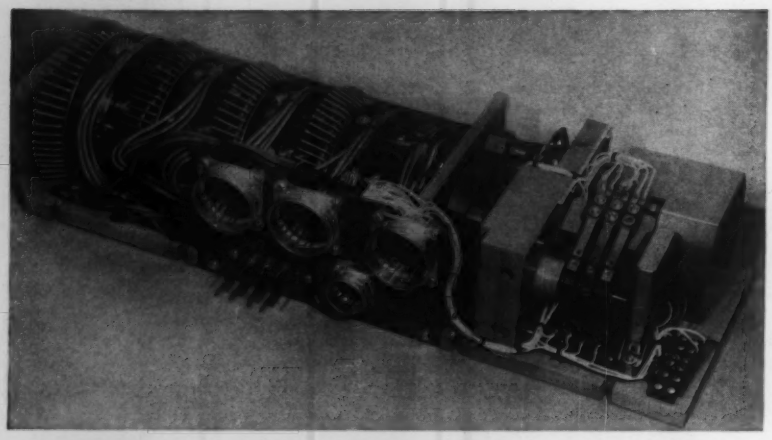
Metals Matters

Chrome plate . . .
of a more durable, pit-free quality is the product of an improved electrolytic hard chrome plating technique developed at Michrom Inc., a division of Gits Bros., Chicago. Plating penetrates every pore of base metal to give a dense, void-free surface that will not chip, peel, or crack. Plating holds oil films without artificial etching, which might otherwise cut through to the base metal and invite corrosion.

Leaded steel . . .
improves machinability of seamless tubing. Tubes of carbon steel with 0.15 to 0.35 per cent lead added have a machinability rating of 85-90 per cent, as contrasted with 72 per cent for the unleaded version. Other mechanical and physical properties of the C-1020 steel used are unaffected, claims Superior Tube Co., Norristown, Pa. Use of the improved alloy is recommended wherever increased production will offset higher price of the material—in most screw-machined parts, for example. Often grinding and other finishing operations can be bypassed, because the new alloy takes a satisfactory finish from standard machining operations.

Refined metallizing . . .
is more than a decorating process, according to NRC Equipment Corp., Newton, Mass. Recent developments include heat-reflective gold coatings to protect missile structures, optically transparent coatings that screen out infrared rays, and capacitors made by metallizing both sides of a nonconducting plate with a conducting metal. Coatings can be varied in density for special effects—domed skylights, for instance, are treated with a thin coat of metal to control the entrance of sunlight. A transparent gold film on the plastic interlayer of car wind shields not only inhibits the entrance of infrared rays, but being an electric conductor, could be used to defrost the windshield as well. Similar techniques may be used on plant windows.

Forging will be hotter . . .
with a castable forging die capable of working at temperatures up to 1600 F. Use of the die will result in work of better quality, closer tolerance, and a cost considerably below that of present high-temperature forging, according to sponsor of the development, Wright Aeronautical Systems Center, Wright-Patterson Air Force Base. Die developer, Armour Research Foundation, Chicago, has also developed a new forging lubricant suitable for use with the high-temperature die.



Transducers Get Workout in New Pressure Scanner

Up to 160 individual pressures are read by 16 transducers in a versatile new pressure scanner. Although the instrument was designed for a specific wind-tunnel application, in which 10 pressures are scanned by each of 16 transducers in a 16-channel system, it can be used in any pressure instrumentation system. Each of the scanner's four rotors will accept four flush-diaphragm transducers, and 40 pressure-line inputs can be connected to each of four stators. Pressure inputs can range from 0 to 100 psia. Designed by Datex Corp., Monrovia, Calif., the scanner is 20 in. long, 6 in. wide, and 4 in. high.

More Noise, Less Cost: Mach-3 Airliners

ST. LOUIS—The next family of commercial jet aircraft will probably fly at three times the speed of sound, according to specialists at the recent ASME meeting in St. Louis. A number of tough technical problems will have to be overcome first, however.

One of the biggest problems will be to equip the exhaust system with a sound suppressor to meet airline requirements, according to G. C. Rapp of General Electric's jet engine department. Rapp says this is probably the most difficult requirement to meet from the standpoint of complexity and reliability. The compromise in engine performance, now accepted in suppressor-equipped subsonic jets, is intolerable in Mach-3 design, he says.

Another noise problem which will be equally difficult to overcome is the sonic boom generated by aircraft traveling faster than sound. The "boom" is not only bad public relations for the airlines, as is exhaust roar, but it can also damage structures on the ground. This is causing the military considerable difficulty at the present time.

Engine shutdown at Mach-3 speeds poses another difficulty not experienced with subsonic aircraft. At high supersonic speeds, there is very little difference—in the engine—between windmilling and normal operating speed It will thus be necessary to curb windmilling—by blockage of airflow, possibly combined with a braking system through the accessory drive—to keep temperature down and maintain the integrity of the engine.

Why Mach 3?

Today's jet airliners travel at speeds of about Mach 0.9. Most industry experts and airline executives predict that the next round of commercial jets will cruise at Mach 3. Reason for the big jump in performance—it apparently costs less to go faster.

According to Fred A. Payne of North American Aviation's Los Angeles Div., "A 15 to 25 per cent reduction in present-day direct operation costs might reasonably be expected of Mach-3 commercial aircraft. And cost of conversion to supersonic jets is the same at Mach 3 as Mach 2. While the faster aircraft may be more expensive, fewer will be needed to handle the same traffic."

Atomic Clock in Orbit Will Check Relativity Theory

Prototype is Being Built Now; Launching Seen in Several Years

NEW YORK—One of the best tests ever made of Einstein's theory of relativity will be provided by a 30-lb atomic clock, housed in a satellite orbiting the earth.

An implication of the Einstein general relativity theory is that a clock running in a gravitational field different from earth's would run at a different rate. The satellite clock would check this and also would:

- Recheck the special law of relativity regarding the "twin paradox." That is, if a human twin could be launched with the clock, he would return less aged than his brother who stayed home. If he could travel 20 years at near enough to the speed of light, he would find the earth millions of years older when he returned.
- Make precise measurement of the geometric shape of the earth, even over inaccessible territory.
- Determine whether space is the same in all directions.
- Measure velocity of light or radio waves.

The clock, which will be accurate to 3 seconds in 3171 years, will be built by Hughes Aircraft Co. under contract from the NASA. Of the maser type, it will generate a highly stable current with a frequency of 24 billion cycles per second. Electronic circuitry will slow these oscillations to a rate convenient for making precise laboratory time measurements.

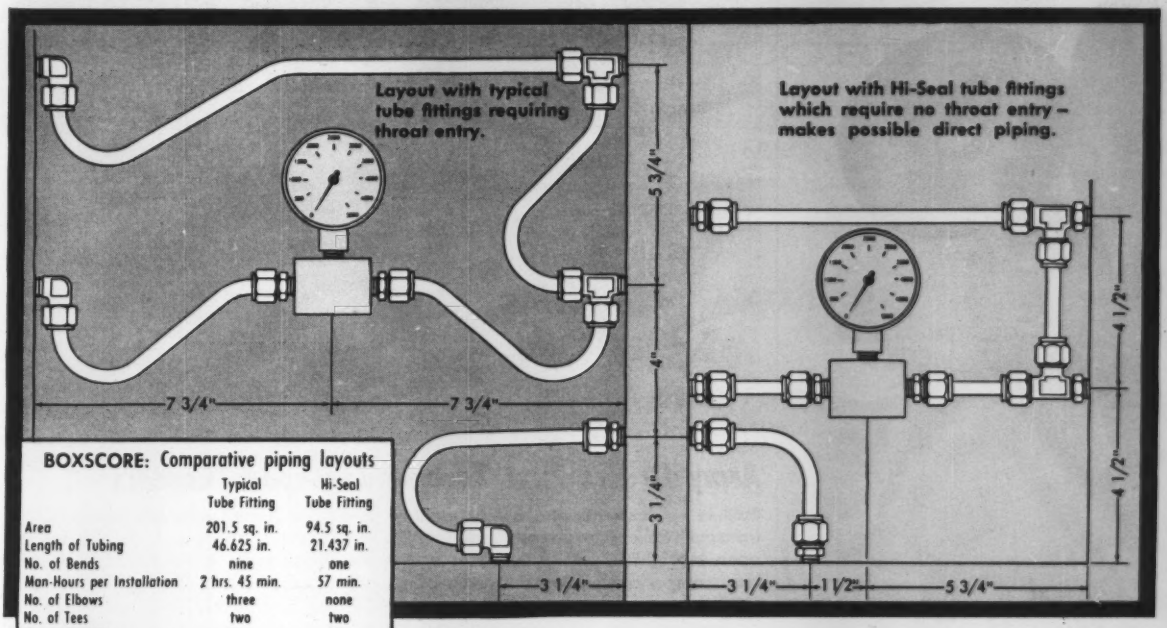
Dr. Harold Lyons, who invented the first atomic clock and now heads Hughes' atomic physics department, says the clock should provide the "most precise check in history on effects of gravity on atomic processes."

In orbit 8000 miles above the earth, traveling about 18,000 miles an hour, the clock should show a time difference of about 1 second in 60 years between itself and its earthbound twin.

Although Einstein's theory is accepted as probably true, scientists would welcome proof. This clock experiment would check out gravitational time dilatation, a fundamental, crucial feature of the theory.

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



BOXSCORE: Comparative piping layouts

	Typical Tube Fitting	Hi-Seal Tube Fitting
Area	201.5 sq. in.	94.5 sq. in.
Length of Tubing	46.625 in.	21.437 in.
No. of Bends	nine	one
Man-Hours per Installation	2 hrs. 45 min.	57 min.
No. of Elbows	three	none
No. of Tees	two	two
No. of Straights	three	six

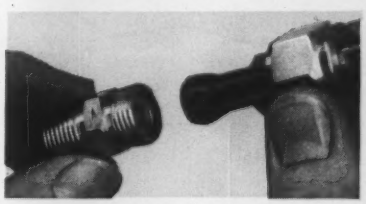
How Hi-Seal saves space—cuts costs

. . . makes possible reductions up to 50% in required piping area . . . up to 66⅔% in installation time!

Imperial Hi-Seal tube fittings open up economical *new piping design concepts* for instrumentation, hydraulic circuits, and other tubing installations. Hi-Seal makes possible far more compact layouts than can be made with conventional fittings — in addition, it brings *new ease and speed* to joint making and utmost reliability.

These design considerations are illustrated in the tubing layouts above. The diagrams show how Hi-Seal actually eliminated nine tube bends . . . saved more than one-half on tubing needed. Total layout area required by Hi-Seal is only 94.5 sq. in., compared to 201.5 sq. in., when an ordinary fitting is used. And 67% *more* manhours were required to tube up the circuit with a typical fitting.

Several key fitting design factors account for Hi-Seal piping economies: (1) Hi-Seal makes a positive butt joint — no need to spring tubing; (2) speedy, foolproof assembly — it is impossible for the fitting to be assembled with the alloy steel sleeve in reverse position; (3) there is no danger of over-torqueing . . . when threads on body of fitting are covered, a pressure-tight seal has been made, a visual assurance of a correct joint; (4) under tests, Hi-Seal fittings have withstood pressure of 4,000 psi at conditions of −320° F. to over 700° F.



with *no* leakage; (5) Hi-Seal fittings can be disconnected and reconnected as often as desired.

Complete line — Hi-Seal fittings are available in brass, steel, stainless steel. Also furnished in Titanium, Tantalum and other metals. Steel fitting supplied with cadmium plate or black phosphate finish. Conform to J.I.C., A.S.M.E. and A.S.A. standards. In sizes for ⅛" to 1½" O.D. tubing. Furnished with Long Dryseal pipe threads or straight thread port seal.

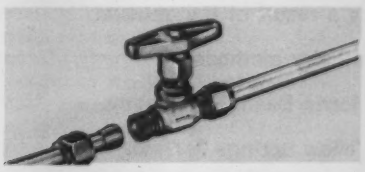
Write for Bulletin No. 3061

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.
In Canada: 18 Hook Ave., Toronto, Ont.

New high-pressure valves assemble directly to tubing — eliminate additional fittings

A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.



Write for Bulletin 3096, or Catalog No. 200

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

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Chicago 48, Ill
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Title .....
Company .....
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City ..... Zone ..... State .....

Circle 415 on Page 19

Army Orders First Turbine Transport 'Copters

Built-in work stands and a rear loading ramp give Army's new Chinook (YHC-1B) transport helicopter unusual utility and serviceability. Loading ramp can be left open in flight to permit transport of items too long to fit in the craft's 30-ft payload compartment. Work stands, plus external access hatches to all major components, make emergency field maintenance comparatively easy. The craft is powered by two 1940-hp shaft-turbine engines which give it a cruising speed of 125 knots. Payload capacity is 33 passengers or 3 tons. Vertol Aircraft Corp. designed Chinook and will build five under Army contract.

Ductile iron fluid couplings to withstand high shock diesel service are cast in quantity. Their smoothness and accuracy save considerable machining time as a result of the unusual foundry methods of Morris Bean & Company, Yellow Springs 2, Ohio.

BEAN

aluminum
magnesium
ductile iron
foundries

Circle 416 on Page 19

Electric Plug-in-Mobile Runs Farther Per Farthing

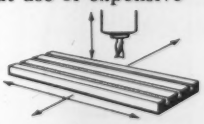
Lightweight electric auto costs about one cent (3 farthings) to run over a three mile stretch of road. Developed by England's Traction Electric Ltd., the small runabout can be charged from the nearest 110 v ac line in 90 minutes (half-charged in 30 minutes) and has a 40-mile range between chargings. Top speed is 50 mph. A lightweight lead-acid storage battery supplies power to a 4 hp motor mounted directly on the differential housing. A chain connects motor shaft to differential input and gives speed reduction. As the accelerator pedal is depressed, it switches banks of battery cells from parallel to series to give successive voltage increases.

MICRO-PATH's *dual track* RECORDING...

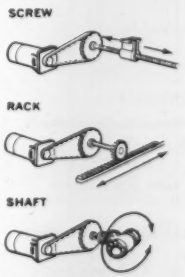
1 billion to 1 reliability in performance!

11 CHANNELS
Micro-Path's magnetic tape accommodates 11 individual tracks, allowing for many prime and auxiliary functions.

MICRO-PATH is the first low-cost automation system, recording programs directly without use of expensive computers or highly trained technicians. It utilizes magnetic tape and is capable of producing motion in any of 3 axes, *individually* or *simultaneously*.



To convert magnetic tape recordings to motion Micro-Path utilizes a special motor known as a PULSERVO. Unique in design, the PULSERVO responds to individual electrical pulses, the armature rotating 5° for each pulse command. A continual series of pulses thus creates continuous rotation, the PULSERVO keeping in step exactly and reversing according to the signal received. The PULSERVO can be attached as a packaged unit to a screw, rack or shaft to automate various types of equipment, from machine tools to industrial controls. This flexibility accommodates installation on existing equipment as well as easy incorporation in new designs.



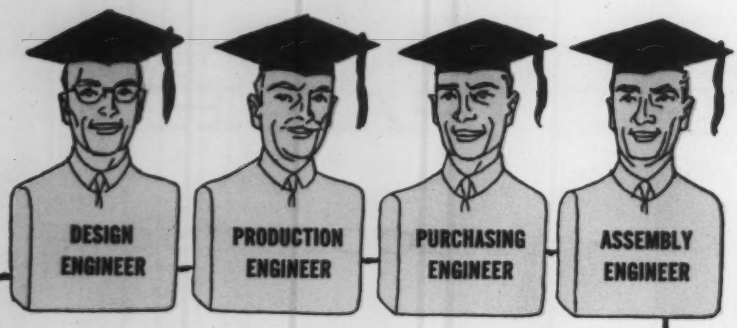
With millions of pulses magnetically stored on each tape the question arises, how dependable is the MICRO-PATH system? During recording, motion commands for each axis are duplicated *in two separate channels*. Playback generates two identical electrical programs in exact unison. These are fed simultaneously to the PULSERVO. Loss even of a single pulse in one channel is remote, but should it occur, an identical pulse is supplied by the opposite track. Dual track recording in MICRO-PATH thus insures an electrical reliability of 1 billion to 1 at the recording head... *equivalent in machine tool operation to .001" in 15 miles of table travel!* Loss of program from external causes such as dust, scratches, wear or other similar defects is thus virtually nil! A closed loop Pulservo system thereafter faithfully follows commands and stays on program.

Our engineers will be glad to tell you how MICRO-PATH can automate your machines or equipment. For the complete MICRO-PATH STORY ask for brochure on your company letterhead!

MICRO-PATH INC.

A Subsidiary of Topp Industries Inc.
4949 West 104th Street • Inglewood 2, California
Phone: SPring 6-0450

Circle 417 on Page 19



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There's **NO** time waste

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There's **NO** grinding

There's **NO** counting

There's **NO** stacking

There's **NO** miking

and there's NO dirt between layers—ever, for those who say

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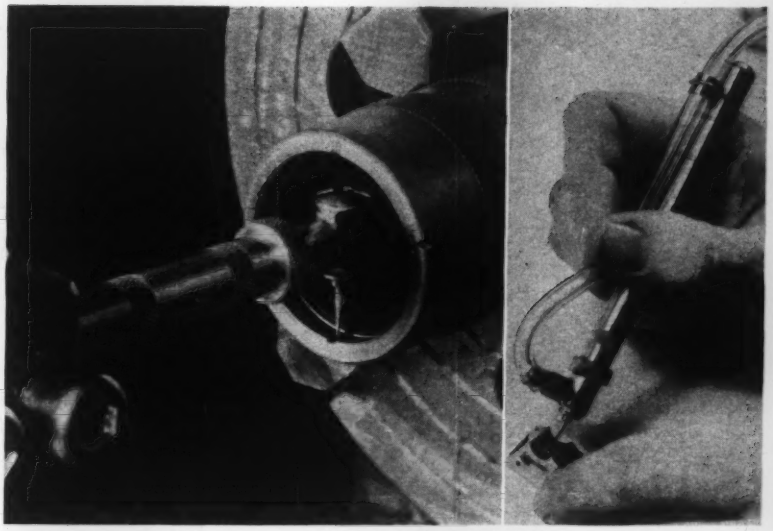
Guy-Lines That Grow

Pneumatic cylinders trusted with the orderly release of Atlas missiles weigh more than a ton. Slightly more than 6 ft long (retracted length), the cylinders expand to almost twice this length before they let go of the missile. Hold-down force, produced by high-pressure nitrogen acting against a piston, is exerted on the launching mechanism. When rocket engines fire, piston pressure is bled-off until thrust exceeds hold-down force and the cylinder starts to "grow." As it extends, cams snap out of engagement, disconnecting pistons from piston rods. Release of the cylinders from the missile is accomplished by a second set of cam-actuated locks. Cylinders were developed by Western Design Div., U. S. Industries Inc., Montebello, Calif.

Drastic Crew Cut Due for A-Subs With Aircraft-Type Controls

GROTON, CONN.—A submarine control system that may permit manpower reduction on atom-powered submarines from the present average 100-man crew to 12 men is currently under development. Target date for placing the integrated control system (SUBIC) in a nuclear submarine is 1964, and the project promises to be of importance

Circle 418 on Page 19



300,000-rpm Grinder Dissipates Heat

Miniature air-power grinder developed by Ashcombe Co., York, Pa., operates at speeds of more than 300,000 rpm while grinding hard materials. Called Airotor, the grinder will machine small holes to a tolerance of 0.0001 in., even in materials as hard as ceramics, glass, carbides, and hard metals. With a vertical milling machine, it produces 1/16 in. keyways in hardened tool steel, left. As a hand machine, it cuts identification letters in a Stellite jig, right. Operating from standard shop air lines, the grinder uses a pressure regulator to throttle air pressure down to 40 psi. The regulator unit also filters the air and mixes it with a fine lubricant. Airotor operates at a speed which dissipates heat from the instrument itself and from the grinding surface. It remains cold in the operator's hands, permitting optimum control and accuracy.

in both small "killer" (antisubmarine) submarines and the big ballistic-missile subs. General Dynamics Corp.'s Electric Boat Div. has been selected by Office of Naval Research as manager of an industry-Navy team working on SUBIC.

Primary purpose of the program is to increase the operational and combat effectiveness of submarines. SUBIC scientists are attempting to create a balanced man-machine partnership that will utilize electronic sensing and data-processing equipment to permit up-to-the-minute tracking of contacts and provide information necessary for precise navigation and weapons firing. A television-type visual display of information will enable the submarine commander to make prompt decisions. In effect, the skipper will have an "electronic porthole" to see his sub-surface environment.

These features are logically adaptable to the latest atomic subs which use one-man, airplane-type controls.

Meetings and Shows

Aug. 9-12—

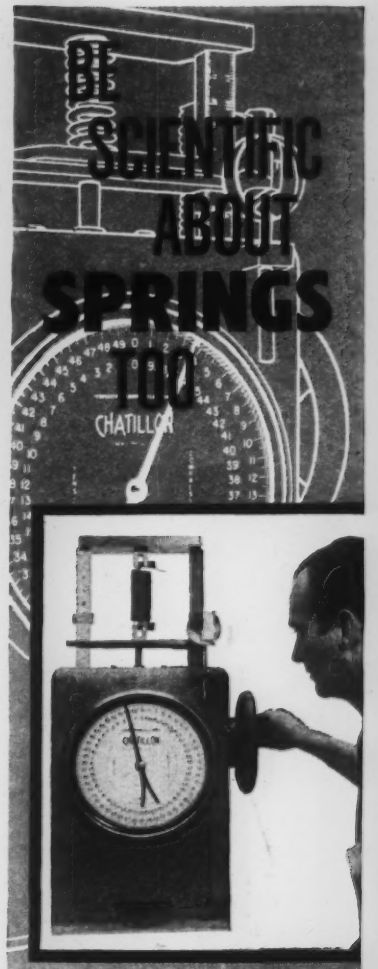
American Society of Mechanical Engineers—American Institute of Chemical Engineers. Heat Transfer Conference to be held at the University of Connecticut, Storrs, Conn. Further information may be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Aug. 10-13—

Society of Automotive Engineers Inc. International West Coast Meeting to be held at the Hotel Georgia, Vancouver, B. C., Canada. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Aug. 17—

Institute of Radio Engineers. First National Ultrasonics Symposium to



Do you use springs in the equipment you manufacture? Do they sometimes fail to pass Quality Control? Would another, cheaper spring do the same job? You can be *sure*, easily, quickly and accurately with a

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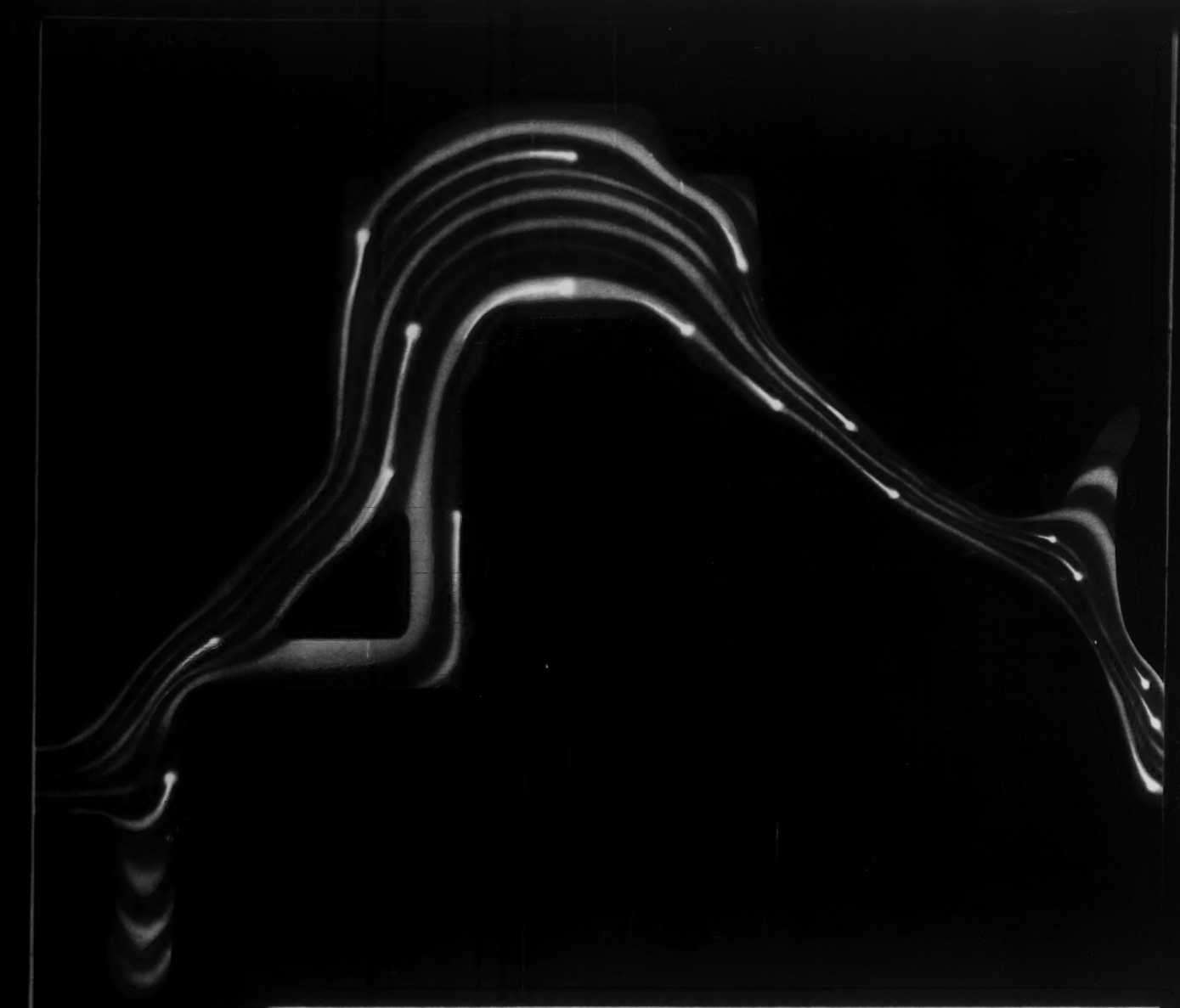


Fluid mapper pattern demonstrating liquid flow through a cross section of a Malleable differential carrier.

Versatility is Malleable

The ability to do most any job well is synonymous with Malleable iron castings. The variety of tasks they perform, from the commonplace to the spectacular, is legend. The strength and toughness . . . the freedom of design . . . the wide range of shapes and sizes . . . the excellent machinability . . . the economies achieved . . . all these advantages of Malleable combine to create an unexcelled reputation for versatility.

Whatever your needs, look first to Malleable.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Versatility Is Key to Malleable's Increasing Use

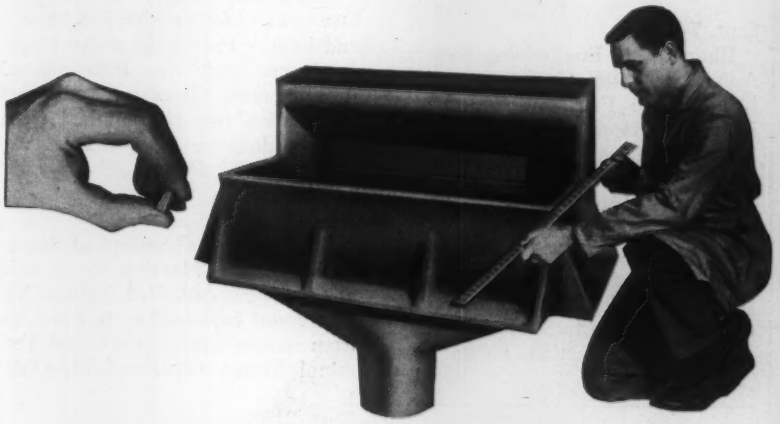
Recent metallurgical advances have made the Malleable irons a family of metals uniquely capable of meeting the most diverse design, production and performance requirements. Whether the vital consideration is high strength, toughness, ductility, hardness, machinability, high or low temperature performance, wear resistance, or economy and adaptability for complicated designs, Malleable castings have the versatility to meet exacting specifications.

For versatility of shape, the casting process is unexcelled. It permits direct production of the most complicated components. The metal is placed exactly where it is needed regardless of the intricacy of the design.

The capabilities of the metal to be cast are of even greater significance, for every application has a different set of requirements. Here, Malleable iron provides unique opportunities to obtain better parts at less cost.

Holes can be punched in Malleable, surfaces can be coined to meet rigid specifications. The pearlitic Malleables can be surface-hardened for even better wear resistance. These and other advantages make today's Malleable iron one of the most versatile engineering materials available.

Although Malleable iron's properties are flexible, depending on service requirements, certain relationships remain constant. Malleable provides more strength and toughness per dollar than any other metal. It is also the most machinable of all ferrous metals of similar properties.



Malleable castings can be produced in sizes ranging from the hammer handle wedge, shown here, weighing less than an ounce, to the 1,125 pound bridge scupper. Throughout this range is an endless variety of castings, best made of Malleable for highest quality at lowest cost.

Shapes and sizes of Malleable castings are virtually limitless. The combination of Malleable's good castability with modern production techniques regularly results in sections as thin as 1/16" and tolerances of ±.005" per inch in sections of 1", with excellent surface finishes.

Engineering Aids Available

While the design of Malleable castings is not complicated, it will pay you to consult a skilled Malleable engineer who can offer time and cost saving suggestions for the production of better parts. As another aid to basic Malleable casting design, a special folder — *Data Unit 104 — Design Versatility* — is available from any member of the Malleable Castings Council and from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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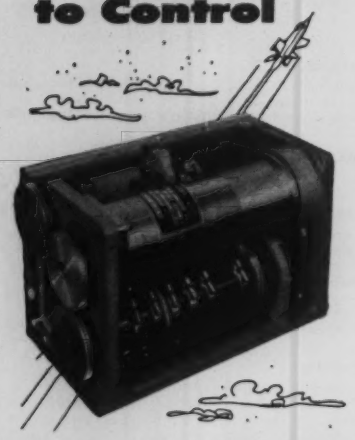
SPECTROL PRECISION MECHANISMS

Pilot to Cockpit to Control



When a test pilot rockets into the outer atmosphere for the first time driving experimental craft such as North American's X-15, he'll feel as though he's been there before.

Before his first actual flight, the pilot trains for many hours in "dry land" rocket craft. There, he learns to cope with upper atmosphere problems as posed by an analog computer. Every time he touches a control, the computer responds and the result appears on the instrument panel in the training cockpit. The entire bank of instruments reacts as though he were really "up there." In this way, the pilot meets every conceivable situation long before he takes his powerful bird aloft.

And what does Spectrol have to do with this important training program?

Spectrol makes the link that joins the computer and the bank of instruments in the cockpit. This link, known as a servo repeater, translates the computer's information into meaningful dial readings. As you know, such information must be transferred quickly and accurately.

Spectrol servo repeaters do just that. Key specifications for a typical unit now in production are:

Maximum velocity: 360°/sec
Acceleration in excess of 7000°/sec²
Static accuracy better than 0.25 deg. at output shaft

Other applications for Spectrol packaged servo repeaters include dial drives on GCA equipment, airborne computers and dc systems in general.

Spectrol PRECISION MECHANISMS free the systems engineer from building functional sub-assemblies. If you need precise logical system modules combining in a *single specification* sub-assemblies using components such as gear drives, clutches, precision potentiometers and servomotors — Spectrol can help.

For complete information, call your nearest Spectrol engineering sales representative, or address Dept. 577-A.

14

SPECTROL

ELECTRONICS CORPORATION
1704 SOUTH DEL MAR AVENUE • SAN GABRIEL, CALIF.

Circle 421 on Page 19

be held in San Francisco. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

Aug. 18-21—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Sponsors are Western Electronic Manufacturers Association and the Seventh Region of the Institute of Radio Engineers. Further information can be obtained from WESCON headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 1-3—

Association for Computing Machinery. 14th National Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Additional information is available from Dr. Frank M. Verzuh, Computation Center, MIT, Cambridge, Mass.

Sept. 7-11—

Illuminating Engineering Society. Annual National Conference to be held at the Fairmont and Mark Hopkins Hotels, San Francisco. Further information can be obtained from IES headquarters, 1860 Broadway, New York 23, N. Y.

Sept. 14-17—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display) to be held at the Milwaukee Auditorium, Milwaukee. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

"This, gentlemen, is what we call a decimal point. Used properly, it can be of great value."

Sept. 17-18—

American Society of Mechanical Engineers—American Institute of Electrical Engineers. Engineering Management Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-23—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Rice Hotel, Houston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-25—

Instrument Society of America. Instrument - Automation Conference and Exhibit to be held at the Palmer House and the International Amphitheatre, Chicago. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-22—

Steel Founders' Society of America. 57th Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-22—

Standards Engineering Society. Eighth Annual Meeting to be held at the Somerset Hotel, Boston. Additional information can be obtained from Charles T. Ajamian, P. O. Box 538, Wayland, Mass.

Sept. 23-25—

American Institute of Electrical Engineers—Institute of Radio Engineers. Nonlinear Magnetics and Magnetic Amplifiers Conference to be held at the Shoreham Hotel, Washington, D. C. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—

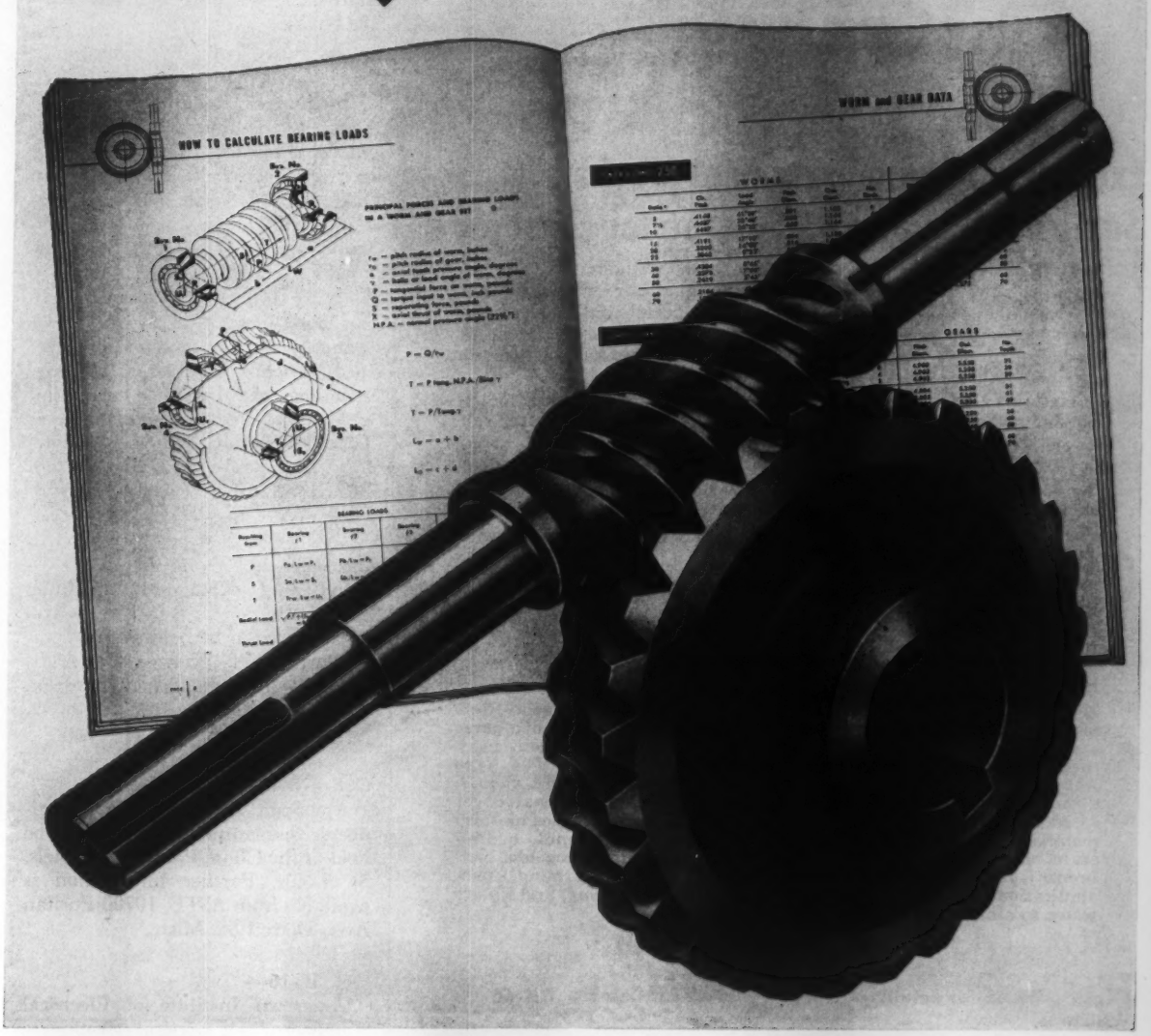
American Welding Society. Fall

DELROYD
WORM GEAR SETS

New high efficiency... higher horsepower ratings

JUST OUT

Send for this new Delroyd Worm Gear Sets Catalog #3800. It contains comprehensive information on selection of worm gears, calculation of bearing loads, and other data, much of which has never been published before.

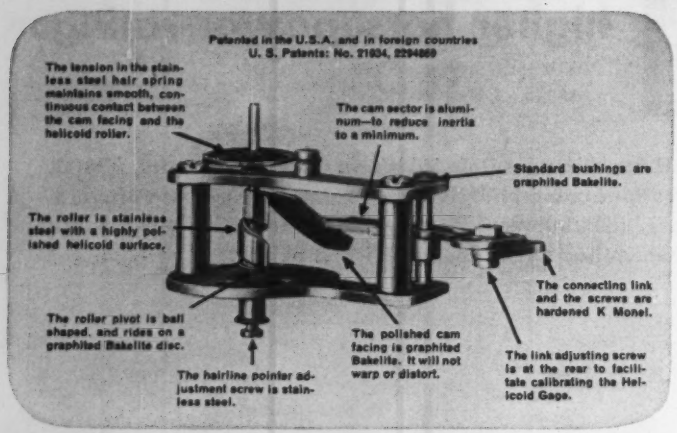


DE LAVAL *Steam Turbine Company*

858 Nottingham Way, Trenton 2, New Jersey

DL-42D

ACCO
Helicoid Gage
U.S.A.


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

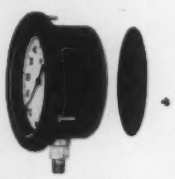
• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection



The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-M Connecticut Ave., Bridgeport 2, Conn.

ACCO

Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—
American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Power Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 30-Oct. 1—
Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Conference to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

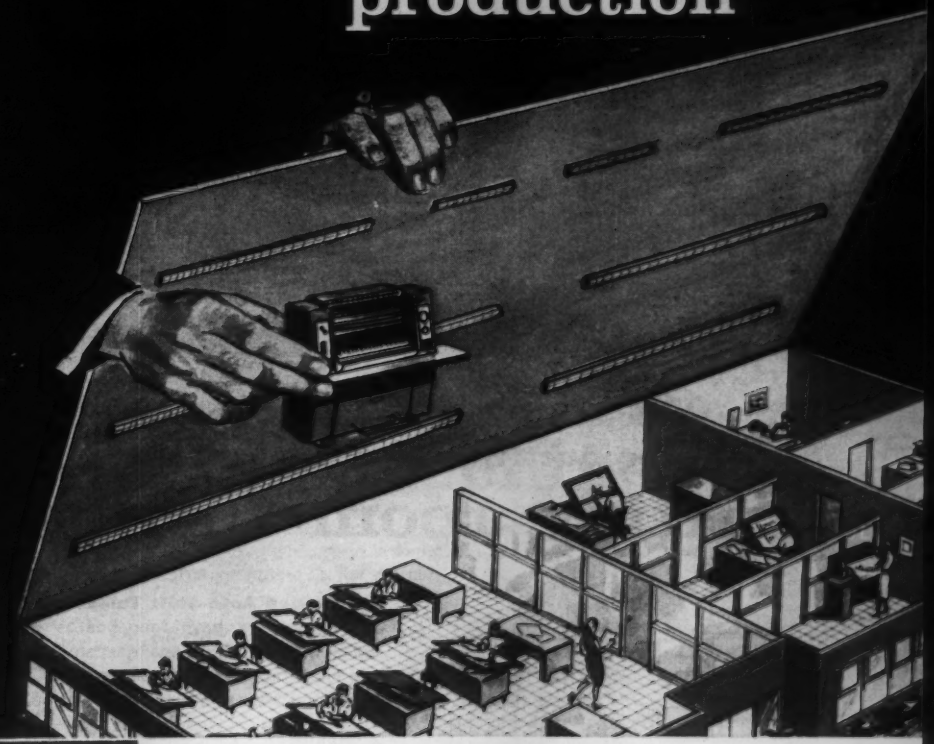
Oct. 5-10—
Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at The Ambassador, Los Angeles. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 7-9—
Industrial Designers Institute. Second Annual Ideas in Design Materials Show to be held at the Commodore Hotel, New York. Additional information is available from Leonard S. Rogers, 19 W. 44th St., New York, N. Y.

Oct. 8-10—
American Society of Tool Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotels, St. Louis. Further information is available from ASTE, 10700 Puritan Ave., Detroit 38, Mich.

Oct. 11-16—
American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

how the Bruning Man raises the "ceiling" on drafting room production



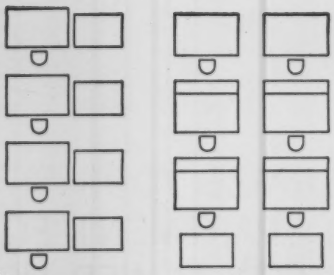
BRUNING

5 WAYS TO MODERNIZE YOUR DRAFTING DEPARTMENT FOR MORE MANPOWER, LOWER COSTS

In this era of fast, intense, and ever-changing engineering progress; drafting departments are being called on for faster, more accurate work. Costly expansion need not be the only answer. Read on the following pages how the Bruning Man's reasonably priced modernization program will more than pay for itself in greater production and lower costs.

modernize to make 50% more productive use of space with

drafting room furniture



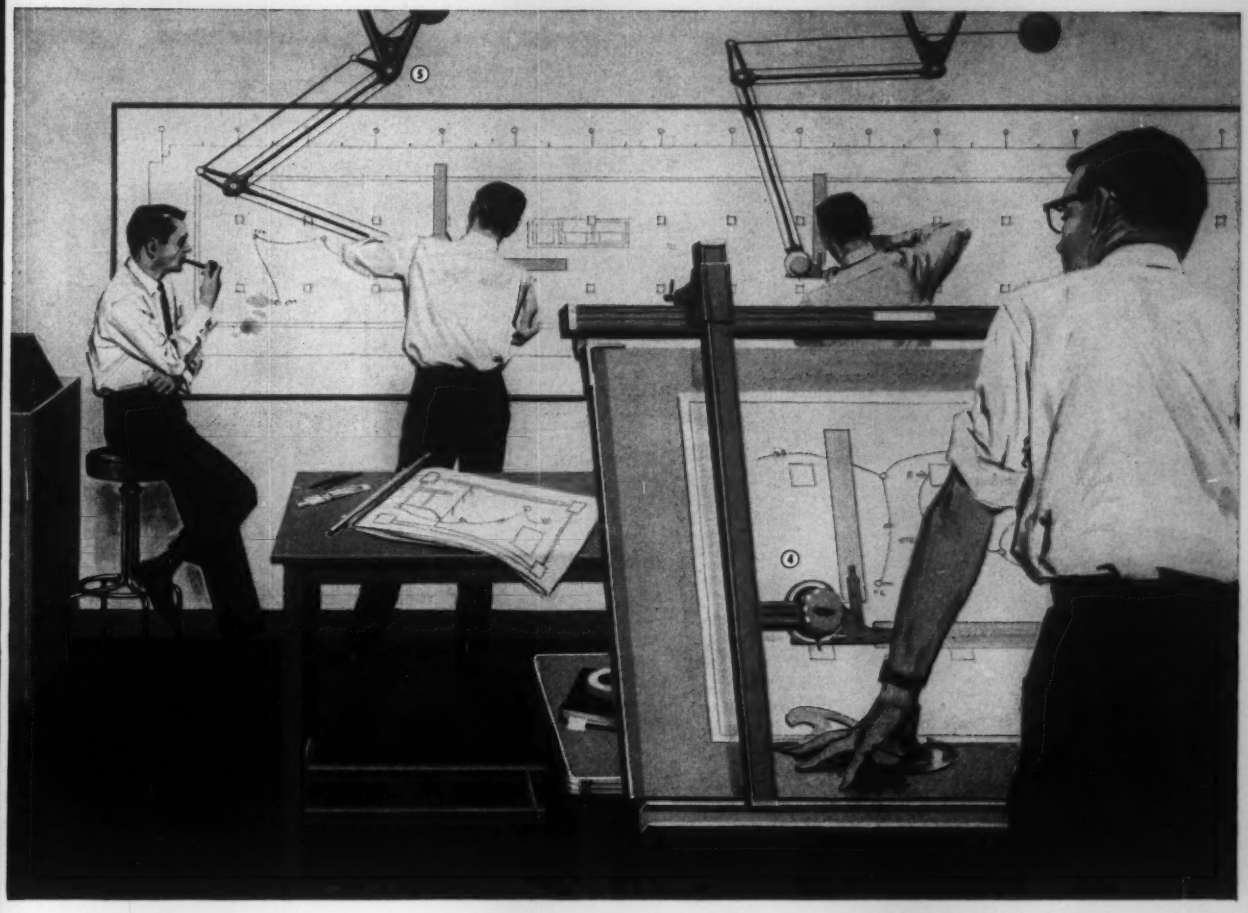
Conventional Arrangement **Auto-Shift Arrangement**

1. Hamilton Auto-Shift Tables. You can put six modern Auto-Shift units where you now have four boards with separate reference desks. Unique design of Auto-Shift lets draftsman work on any part of the board, reach reference table and drawers without leaving his seat. Your draftsmen work faster and better with far less fatigue.

2. Hamilton "L" Contour Tables. The unique "L" shape of this combination board and desk unit provides new reference convenience, new personalized working space, new smartness of surroundings for modern draftsmen and engineers. They work faster, better, and with more pride in their work and surroundings.

3. Hamilton UnitSystem Files. You file drawings and records in units especially designed for them by size and frequency of use. Drawings are faster to file and find. UnitSystem's interlocking feature lets you combine exactly the units you need in higher stacks to save space and to expand filing efficiently and economically.

BRUNING



modernize to speed drafting up to 40% with

drafting machines

Over conventional equipment, modern Bruning drafters speed drafting up to 40% on most jobs . . . up to 50% on some structural drawings. They are far faster and easier to operate than any other drafting machine on the market.

4. All-New Neoglide Drafters. A complete departure from conventional drafting machine design, Bruning's new Neoglide drafters give the draftsman complete maneuverability on any board **at any angle.** Reinforced U-beam construction offers amazing rigidity, strength, and accuracy. Yet resistance-free movement of the counterweight and vertical beam provide free-and-easy "floating" action. No cables or belts to break, stretch, or sag. Touch-control protractor head gives automatic, pin-point angle selection at a touch of the control button.

5. Bruning Track Drafters. Here is the modern, space-saving way to turn out large drawings, faster and more accurately. Unsurpassed anywhere, Bruning track drafters offer automatic indexing, double veniers, and fast scale changes. Models available to provide vertical coverage up to 84″ and unlimited horizontal coverage.

The Bruning Man Gives you the Help you Need When you Need It. He's Located in Principal Cities of U. S. and Canada.

BRUNING

modernize to speed reproduction, eliminate upkeep with

reproduction machines

There's a Modern Bruning Copyflex Machine to Meet Every Need and Budget.

Model 675

Model 35

Model 250

Model 300

Copytron Microfilm Printer

Model 42

1. New Copyflex 675. Years ahead of any reproduction machine, Bruning's Model 675 offers a host of new time-and-work-saving advantages. These include a four-way tracing tray that adjusts to stack or permit fast removal of tracings . . . a feed band system that eliminates curling of tracings . . . enclosed easy-to-load feed rods for roll stock . . . unique system of vacuum ports in the feedboard that hold large sheets and roll stock in position . . . a split-shade lamp control that enables simultaneous insertion of different materials . . . and an electrically controlled push-button machine height adjustment. It offers a mechanical speed of up to 75 f. p. m. and a fast-printing 7,500 watt lamp variable to 5,000 watts, takes sheets and roll stock up to 42" wide.

2. Modern Copyflex 300. This unique, low-cost table top model offers a full 30-inch printing width, gives you professional prints in seconds. By supplementing your main reproduction center with strategically located 300's, you add new dimensions in convenience and economy to your department.

Copyflex machines are odorless, require no venting or plumbing. 8½ x 11" prints cost 1¼¢ each for materials.

BRUNING *Copyflex*® Low-Cost Diazo Reproduction at Its Best!

Circle 426 on Page 19

Call the Bruning Man. His experience and knowledge can save you time and money.

modernize to slash time of re-working drawings up to 90% with

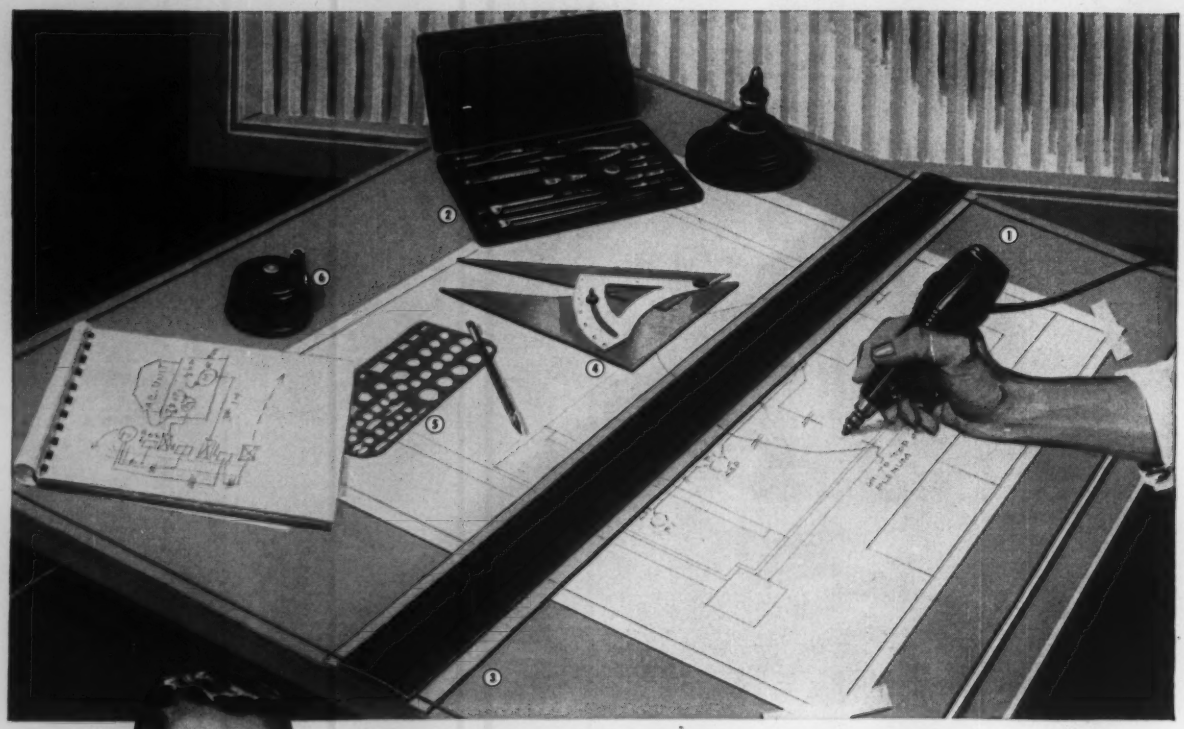
intermediates

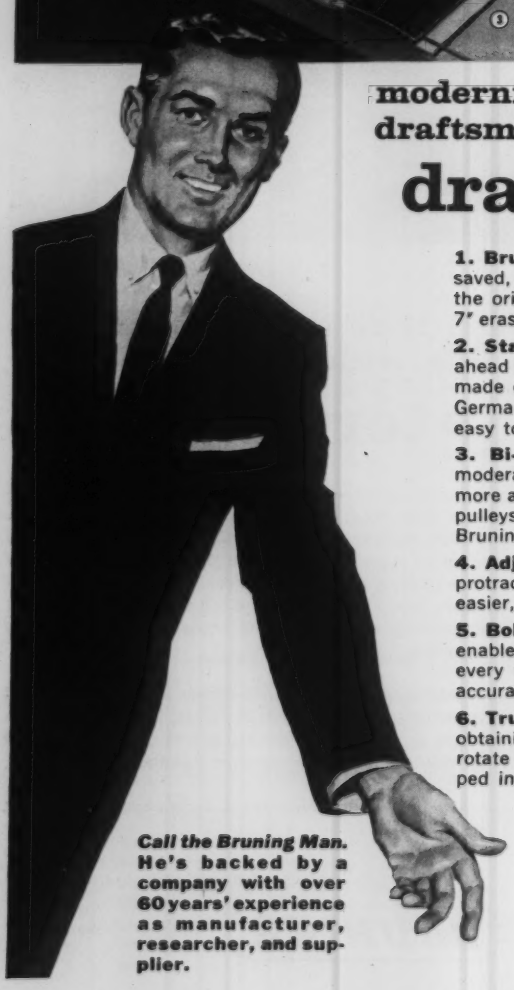
3. For design changes or re-working old drawings, modern Bruning intermediates can save up to 90% of the tracing usually required. The draftsman has a Copyflex intermediate (reproducible print) made of the original drawing. Unwanted portions can either be masked out in the printing operation or eradicated on the intermediate itself. New lines then can be added to the intermediate without the tedious, time-taking work of tracing those sections which do not require alteration.

Bruning versatile intermediates are also widely used to speed and simplify print distribution. Sent to distant points, intermediates can be used again and again to make needed prints or to incorporate changes without waiting for new prints from headquarters.

Bruning's complete line of intermediates include paper, matte film, clear film, and cloth.

BRUNING





modernize to speed and simplify draftsmen's work with

drafting aids

1. Bruning Electric Eraser. Minutes add up to hours of time and work saved, over manual erasing, with Bruning's newly improved electric eraser. It's the original hollow-shaft eraser, more widely used than any other. It features 7" erasers, finger-tip "on-off" switch.

2. Stainless-Supreme Drawing Instruments. You'll be time and money ahead with higher precision, durability, and beauty offered only by instruments made entirely of non-tarnishing stainless steel. 5 times harder than brass or German silver. Specially hardened, swivel-type ruling pen points are fast and easy to clean.

3. Bi-Liner Parallel Straightedge. Over conventional T-squares, these moderately priced straightedges more than pay the price difference in faster, more accurate drafting. Features include: warp-proof blade, ball bearing blade pulleys, full length duraluminum tunnel, board-top mounting attachments. Bruning's complete line includes special model with retractile rollers.

4. Adjustable Triangle. This modern precision tool combines the functions of protractor and universal triangle to enable draftsmen to draw all angles faster, easier, and more accurately. Will not discolor or become brittle. Range of sizes.

5. Bolts and Nuts Template. Bruning's wide variety of modern templates enable faster, neater, more uniform execution of symbols and shapes for every type of drawing. Precision-cut from wear-resistant plastics to assure accuracy and durability.

6. Tru-Point Lead Pointer. Here is the fast, convenient, pleasant way of obtaining clean, ideal draftsman's points. Only one hand need be used to rotate pencil and pointer top around stationary base. Graphite dust is trapped inside. Abrasive liners are replaceable.

***Call the Bruning Man.* He's backed by a company with over 60 years' experience as manufacturer, researcher, and supplier.**

BRUNING

Charles Bruning Company, Inc.
1800 Central Road, Mount Prospect, Ill.
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CLAD REX

The broad effect of CLAD-REX® on industrial design, engineering, and selection of materials

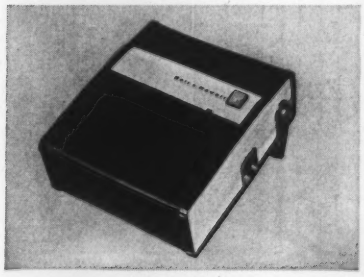
Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Specifically, a calendered, semi-rigid poly-vinyl chloride film bonded to sheet metal. All alloys and tempers of aluminum and steel (including galvanized and aluminized) are commonly used. However, other metals can be used where their special properties are important to end product performance.

The sales appeal of Clad-Rex vinyl-metal laminate

The words *calendered* and *film* mean styling in Clad-Rex is unlimited, because film can be printed. Simulated wood-grains and leathers, as well as any color, combination of colors, texture or pattern can be used. Or you can design your own, if you prefer.



This unlimited choice ranges from sparkling burnishes including high metallics, to non-reflective matte finishes (or variations between) as well.

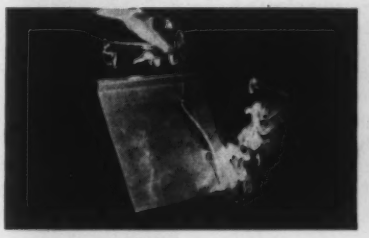
The abrasion resistance of Clad-Rex vinyl-metal laminates

The words *semi-rigid* and *poly-vinyl chloride film* mean Clad-Rex has unusual resistance to abrasion. Therefore, products made of Clad-Rex are more durable and suited to usage where abrasion resistance is required.

However—most important to manufacturing—Clad-Rex can be processed without the careful handling or rejects common to other pre-finished metals. This advantage in itself results in a substantial saving in cost. Even the finishing of *un*finished metals leads to a reject factor that becomes a savings when Clad-Rex is used.

The corrosion resistance of Clad-Rex vinyl-metal laminates

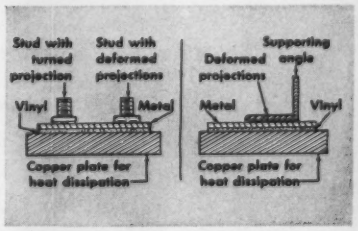
The words *poly-vinyl* and *chloride* become important again, because of the inherent properties of the Clad-Rex vinyl. It provides excellent resistance to acids and alkalis, as well as other corrosive chemicals. It also has high dielectric properties.



The fabrication of Clad-Rex vinyl-metal laminates

Clad-Rex can be formed in almost as many ways as any *un*finished sheet metal—including deep drawing!

Resistance welding, generally, is limited to projection techniques.



However, the resistance welding equipment must be (1) tooled for series welding procedures (both electrodes on same side of sheet), and (2) capable of very short weld times with extremely fast follow-up of forging pressure.

Epoxy resins are proving quite successful for assembly. Clamps can be eliminated by using resistance weld tacking or interlocking design.

The cost advantage of Clad-Rex vinyl-metal laminates

As a purchased material going into a user's plant, vinyl-metal laminates cost more than *un*finished or some other pre-finished metals. *But, most important, end products made of Clad-Rex generally cost less!*

The reasons are worthy of close examination:

(1) Parts made of Clad-Rex require no further finishing. This is a savings in equipment, finishing material, factory floor space, labor, handling, etc.

(2) The abrasion resistance of Clad-Rex substantially reduces (and often eliminates) rejects. This includes both rejected products *and* the expensive handling, reworking activities, and labor required.

The broad effect of Clad-Rex vinyl-metal laminates on manufacturing literally simplifies your processing operations. Movement of sub-assemblies, etc., through your plant actually becomes more direct—out of your dies into assembly!

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. Free of charge, a Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product. **Clad-Rex Division of Simoniz Company, 2113 Indiana Avenue, Chicago 16, Illinois. Telephone: VIctory 2-7272.**

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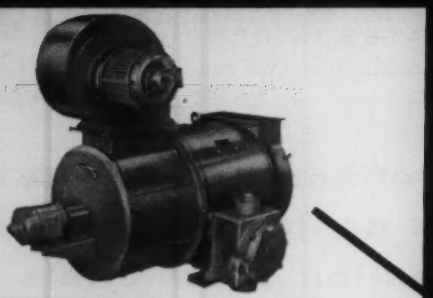
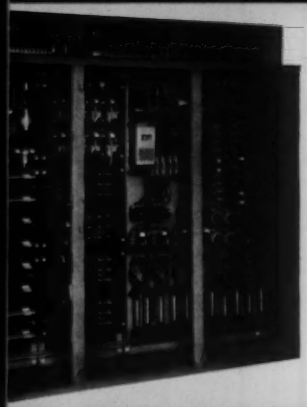
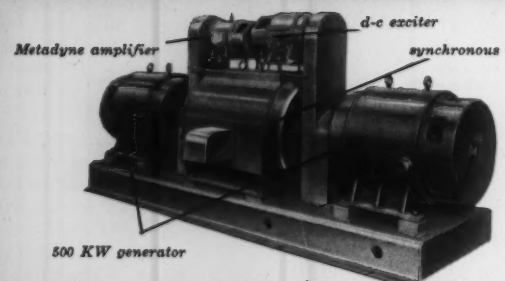


1. Six 100 HP D.C. reversible motors work in unison to drive the antenna through a wide speed range. A blower with its own A.C. motor and filter cools the motor. The D.C. feedback tachometer generator closely co-ordinates the effort of all the motors.

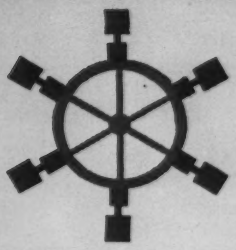
Drives designed and built by Louis Allis



2. Control panel receives, co-ordinates and limits power to give precise selected motor speeds from full forward to full reverse with a twist of a knob — without shock to the antenna or pause in operation. The operator selects the direction of operation and motor speed — the control system does the rest.



3. Industrial type synchronous motor-driven motor-generator set delivers 500 KW of D.C. power to the six antenna drive motors. The D.C. exciter and metadyne amplifier provide a temperature-compensated, automatic controllable source of power to the motor and generator fields.



Each of six drive motors is geared to the antenna bearing. All six are used for normal operation; however, one could operate the antenna in an emergency. Several motors can be cut out without impairing antenna rotation.

New-design news from Louis Allis

Here's precise speed control... Regulation — 0.25%... Response — 0.2 seconds!

System provides accurate, split-second control for rotating radar antenna—another example of complete power-package engineering by Louis Allis.

Today's high-speed heaven-scanning calls for giant radar tracking units with rapid, exact, co-ordinated control. To meet this requirement, Louis Allis engineers recently developed a complex power package which combines an MG set, metadyne amplifier, d-c drive motors, feed-back equipment, and complete controls into an efficient system permitting antenna rotation at exact selected speeds.

Antenna drives may not be *your* problem — but whatever your industry requirement is — steel, paper, machine tool, etc. — you can rely on Louis Allis application and engineering know-how to design and manufacture the drive and control system you need.

Louis Allis expert application specialists are men who know the motor and drive requirements and many of the operating problems of almost every industry. Make use of their experience and take advantage of the unmatched line of Louis Allis standard and special motors and drives to solve your next speed-control requirement.

Get full information from your local Louis Allis District office, or write The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

For specific information on Louis Allis adjustable speed drives and high frequency equipment, write for: Bulletin 2000, Select-A-Spede® Drives; Bulletin 611-E, Ajusto-Spede® Drives; Bulletin 1500, Electronic Select-A-Spede drives; and Bulletin 2250, High Frequency Equipment.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

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ASD-118

How to contain a jet engine

THE BALTIMORE STEEL COMPANY makes shipping containers for aircraft engines, torpedoes, missiles, and other ordnance items. The containers are designed to accompany their cargo almost into the enemy's teeth. They are impact-resistant, shock-mounted, hermetically sealed, pressurized and humidity-controlled.

There were three reasons why the designers selected USS COR-TEN High-Strength Low-Alloy Steel for the outer shells of these containers:

1. The contents demand that the containers be strong and impact-resistant . . . tactics demand that they be light and maneuverable. USS COR-TEN Steel has a minimum yield point of 50,000 psi—50% higher than carbon steel—so it can be used in stronger, thinner, lighter gages, saving as much as 100 lbs. per container.
2. To permit storage in the field, the containers must be highly corrosion-resistant, and USS COR-TEN Steel has four to six times more atmospheric corrosion resistance than carbon steel. The containers are reusable—have a service life of about ten years.
3. COR-TEN Steel saves money. First, its strength permits the use of *less* steel, cutting production costs an estimated 8%. Second, maintenance costs are reduced because paint life on COR-TEN Steel is 50 to 100% longer.

U. S. Steel produces three brands of High Strength Steels—COR-TEN, TRI-TEN, and MAN-TEN, in addition to the remarkable USS "T-1" Constructional Alloy Steel, and a complete line of stainless steels. Each has characteristics that make it ideal for special design applications. For complete information about these "steels that do more," write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS, COR-TEN, TRI-TEN, MAN-TEN and "T-1" are registered trademarks

USS

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American Steel & Wire—Cleveland
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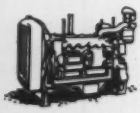
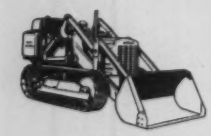
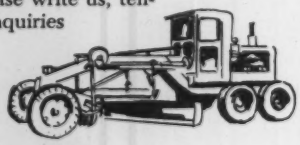
Find the satisfaction of *growth* and *stability* within a *growth* company – where imaginative men are creating products for highway construction – industry – farms – national defense – products which build a better world.



Caterpillar offers top ranking Research and Development opportunities – stimulating assignments – professional and personal advancement. You'll associate with the leaders and pioneers in this field – and have at your command the finest equipment, laboratories and development facilities. Please write us, telling all about yourself. Inquiries are confidential, of course.





(Below – New Caterpillar Technical Center presently under construction)

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Circle 431 on Page 19

Circle 432 on Page 19→

save 6 ways

on assembly time

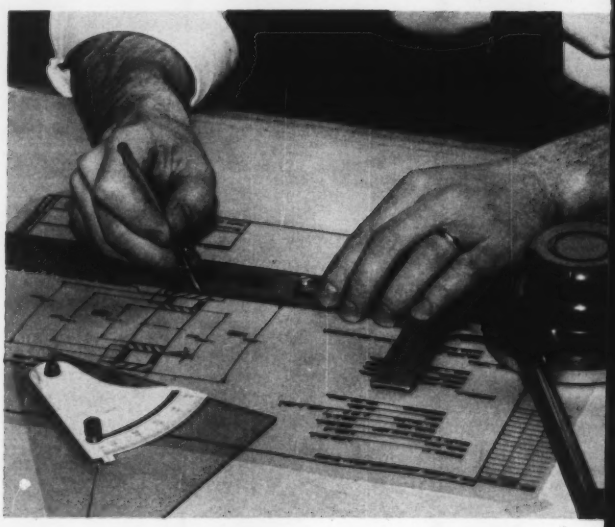
and cost...

HYATT

HY-ROLL BEARINGS

ASSEMBLY AND DIS-ASSEMBLY

when you design around HYATT separable metric series bearings



6 WAYS HYATTS HELP SAVE TIME AND COSTS

1 HEAVY PRESS FITS ELIMINATE RETAINING DEVICES. HYATT inner races are made from carburized type steel. This permits heavier press fits, mountings of the simplest type and lowest over-all cost. When press fitting recommendations are followed, HYATT inner races become an integral part of the shaft for all practical purposes. Auxiliary retainers are practically never needed—an important cost-saving factor.

2 INTERCHANGEABLE PRECISION PARTS ELIMINATE SELECTIVE FITTING. Any separable race in the metric series of HYATT Hy-Roll Bearings will fit perfectly with any related race and roller assembly. Slow and costly selective fitting is never necessary except in the most unusual circumstances.

3 SEPARABLE CONSTRUCTION PERMITS MORE FLEXIBLE ASSEMBLY. For example, HYATT inner races can be pressed on shafts in one location while the outer races and rollers are installed in housings in another area, When the sub-assemblies are brought together the bearing parts will match perfectly without selective fitting.

4 WIDER INNER RACES ELIMINATE SPACERS, SIMPLIFY SEALING. Often an inner race from a wide or double-row HYATT Hy-Roll bearing series can be used with a roller assembly from a narrower single-row bearing series. The extra width of the inner race provides an inexpensive hardened and ground surface upon which a seal can operate more efficiently, and at the same time frequently makes spacers unnecessary.

5 UNITS CAN BE DIS-ASSEMBLED WITHOUT BREAKING PRESS FITS. The design of separable HYATT Hy-Roll bearings permits roller assemblies to be removed, in most cases, without disturbing the press fit of the inner race on the shaft, thus saving costly labor.

6 SPARE SHAFTS CAN BE SHIPPED WITH INNER RACES ALREADY MOUNTED. Gears and other parts will usually slip over separable HYATT Hy-Roll inner races, so races can be pre-shrunk in place on replacement shafts without interference with later assembly. This frequently permits important reductions in downtime and labor costs.

NO BEARINGS CARRY RADIAL LOADS LIKE *CYLINDRICAL*

IS SO MUCH SIMPLER . . .

As labor rates continue to mount and the pressure to cut assembly cost increases, it becomes more and more evident that *it is not the first cost but the INSTALLED cost of a bearing that counts.* HYATT Hy-Roll bearings can help you "design in" significant installation savings which are often overlooked. Here are four concrete examples:

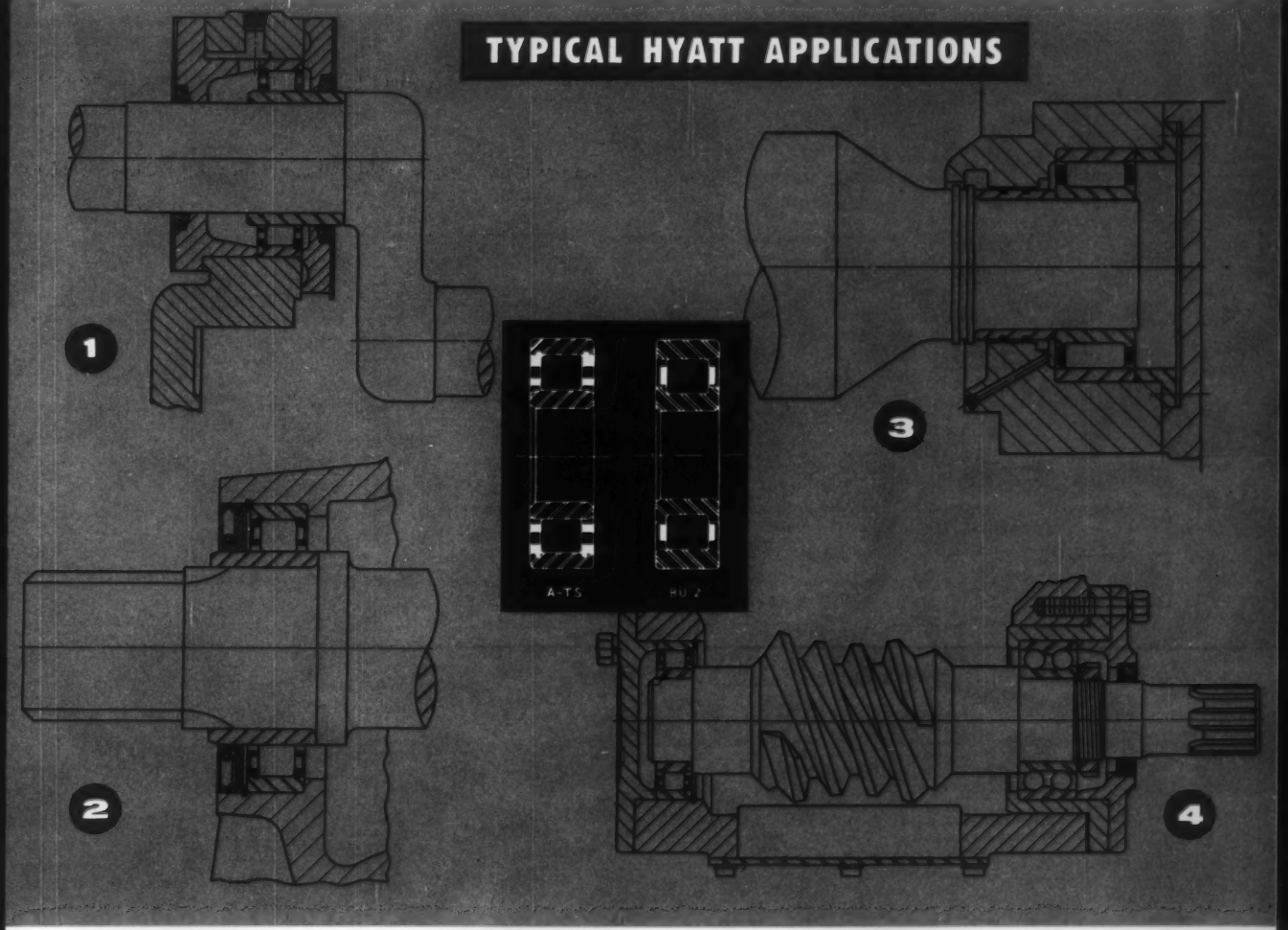
1 **In this loom crankshaft** an A-TS type bearing using an interchangeable inner race from a wide series bearing permits considerable end float in the bearing. This provides clearance for considerable tolerance stack in a long crankshaft. The long inner race also provides a hardened and ground surface upon which the seal can operate best.

2 **A two-part A-TS bearing** in which a long inner race is pressed on the shaft. The extra length inner race is utilized as a seal operating surface. A snap ring pressed in the housing bore serves as bearing retainment and helps to locate the seal.

3 **In this table roll** application a BU-Z type bearing permits sufficient float through the bearing to provide for shaft expansion from high heat conditions without cramping the bearings. The use of separable outer race bearing permits easier installation and removal.

4 **In this worm and gear** application the double-row ball bearing is used for locating the shaft in both directions. The A-TS bearing at the opposite end is used with a cartridge that facilitates adjustment by shimming. Using a cylindrical bearing at one end facilitates assembly and permits easy removal of the worm from the case.

TYPICAL HYATT APPLICATIONS



BEARINGS . . . AND NOBODY KNOWS THEM LIKE HYATT

YOU CAN DEPEND ON THE ADVICE OF YOUR HYATT SALES ENGINEER

...and the bearings he recommends!

Your HYATT Sales Engineer is thoroughly familiar with all the optional cost-saving features which help make installation, assembly and dis-assembly more economical with HYATT Hy-Roll bearings. Long experience with a wide variety of industrial bearing applications qualifies him to make intelligent recommendations which you can depend on to assure lower over-all costs and superior performance for your products.

just call your nearest **HYATT** *office:*

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332 S. Michigan Avenue
Chicago 4, Illinois • HArrison 7-8277

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702 Grant Building
Pittsburgh 19, Pennsylvania • ATlantic 1-2927

DETROIT
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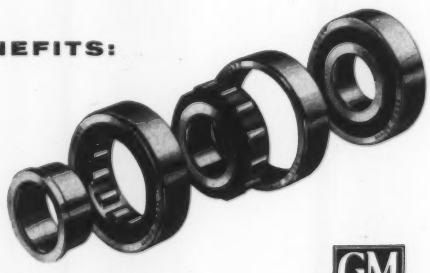
REMEMBER THESE BUILT-IN HYATT BENEFITS:

- Higher radial load-carrying capacity, size for size
- Minimum space requirements
- Omitted races are optional
- Shaft location without sacrificing capacity
- Easier assembly and disassembly
- Heavier press fits simplify retainment

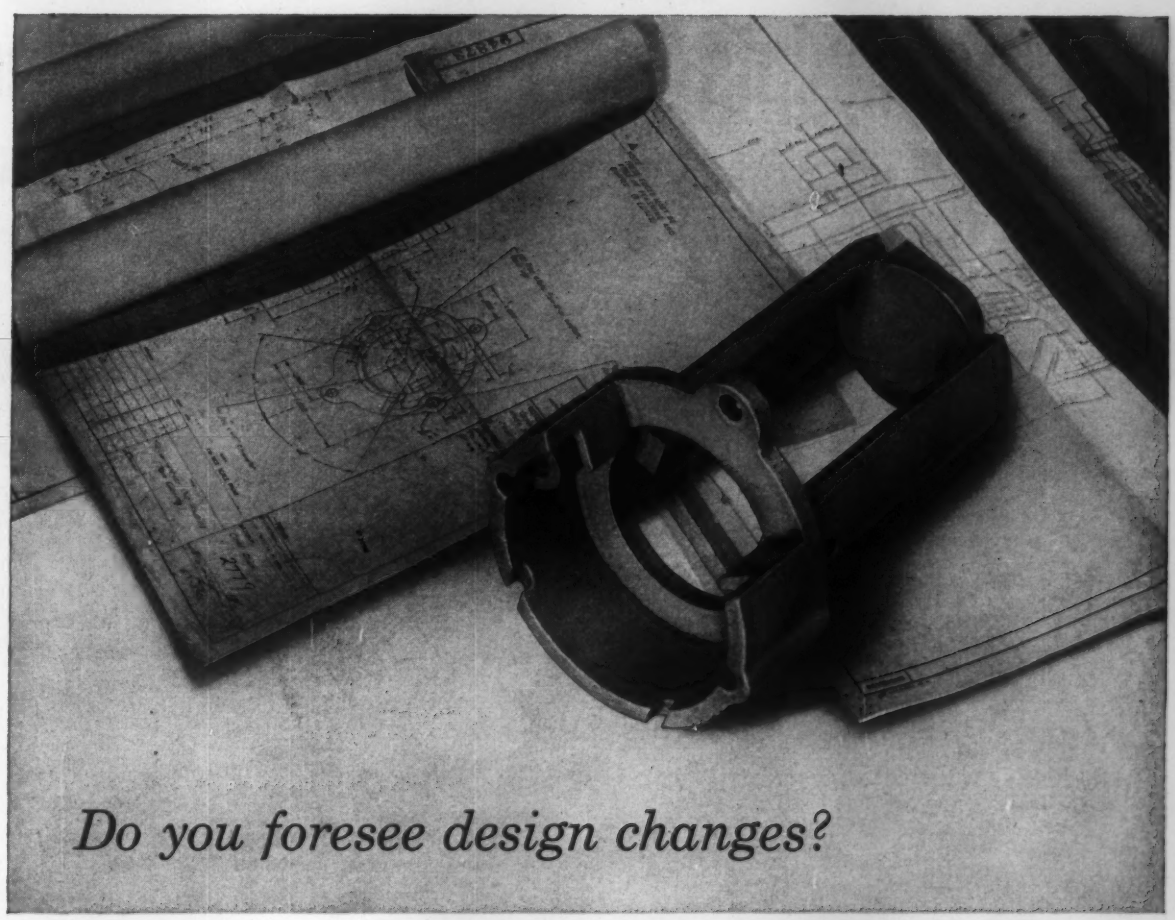


THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



...ask Arwood about investment casting

Investment casting offers you just about the most inexpensive, convenient way you can find to get your new part from the drawing board to finished, production line quantities. This is especially true when your design may involve some degree of complexity... a strong, tough alloy... time-consuming machining steps ... expensive tooling.

There are good reasons. With investment casting, tooling is quick and inexpensive. It's easy to modify finished dies as the need for design changes develops. Even more important, Arwood will handle the whole job for you, from blueprints through to the finished part.

It makes no difference what metal or alloy you specify; Arwood casts a complete range of ferrous and non-ferrous materials. The skilled toolmakers at each of our four foundries can turn out fifty or more dies each week. So to save time and cut your costs between the drawing board and finished parts, ready for assembly, get in touch with Arwood.

Write today for your free copy of the new 44-page Arwood "Practical Guide to Investment Casting." It provides all the information you need to evaluate the technique and use it to help solve your design problems.

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arwood

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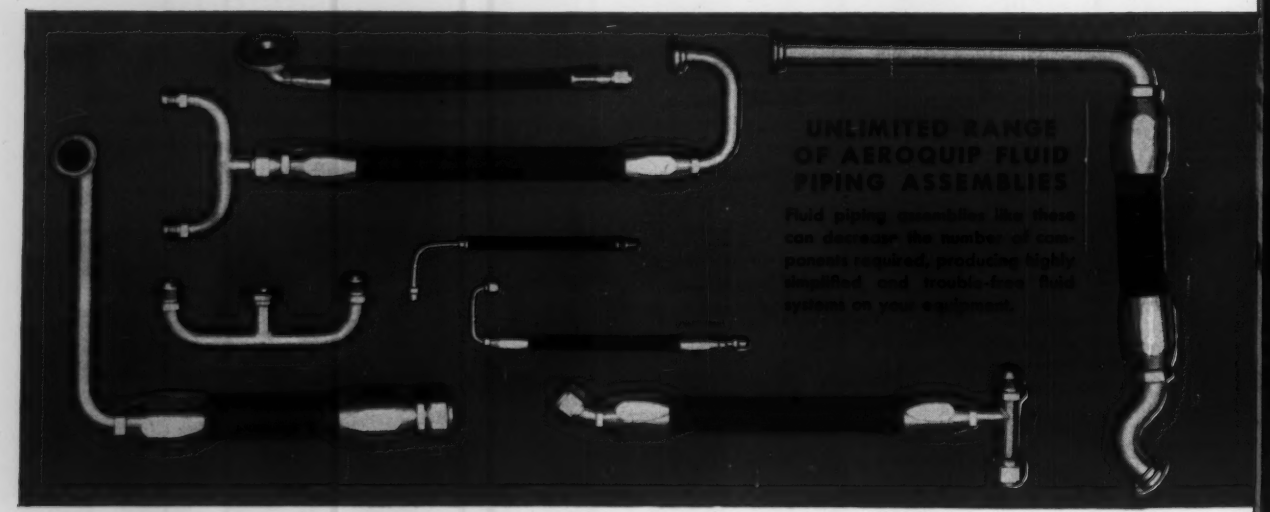
Circle 439 on Page 19

How Aeroquip's Fluid Piping Prototype

Aeroquip field engineers work right with your engineers in building prototypes, assisting in testing and modification of fluid systems to get good performance and long service in the field.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OF AEROQUIP FLUID
PIPING ASSEMBLIES
Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

Service Assists Manufacturing Firms

AEROQUIP'S EXPERIENCE SIMPLIFIES FLUID PIPING ENGINEERING AT THE PROTOTYPE STAGE, ELIMINATES POSSIBLE FUTURE PROBLEMS FOR MANUFACTURERS OF MAJOR EQUIPMENT

Checking fluid piping performance on equipment prototypes is an important part of the complete fluid piping service provided by Aeroquip's skilled engineering team.

The prototype stage in equipment development is the best time for experienced Aeroquip specialists to check routing, sizes, support clamping, lengths, fittings and adapters on fluid piping. Their recommendations will help insure maximum performance and long life. And many problems that might arise on the production line can also be prevented at this stage, thus avoiding costly changes later on.

In providing start-to-finish engineering service, including assistance in design, prototype plumbing, production, service parts and after-sales service in the field, Aeroquip accepts full responsibility for performance.

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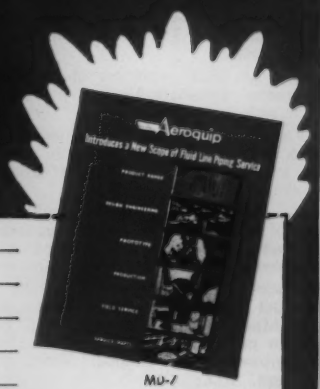
With Aeroquip's prototype installation report as a guide when making production drawings, hours of drafting time are saved.

Properly engineered fluid piping on your equipment assures increased user satisfaction and fewer field service complaints. Aeroquip Flexible Hose and Reusable Fittings greatly reduce downtime and replacement costs.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN



Special Literature Available

Aeroquip Corporation, Jackson, Michigan

- ☐ Please send me a copy of Bulletin 614 explaining your complete service of fluid system design and performance.
- ☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

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MD-7

HI-FI QUALITY SECURED AT LOWER ASSEMBLY COSTS

Thomson Rivets and Rivet-Setting Machines used by H. H. Scott to standardize fastening procedures.

Any high fidelity hobbyist will tell you that H. H. Scott, Inc., Maynard, Mass., makes America's top quality in high fidelity equipment.

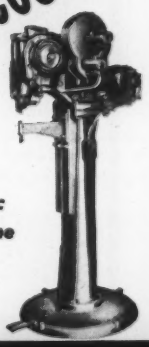
Here you see one of the finest stereo amplifiers made . . . in both chassis and final form. Components are securely and accurately held in uniform tension by 113 Thomson Rivets. H. H. Scott has standardized on Thomson aluminum rivets in one diameter and four lengths.

Rivets get their uniform clinch from any one of the eight Thomson Automatic-Feed Rivet-Setting Machines which H. H. Scott now uses.

All eight machines have identical tooling except for interchangeable anvils. Several sets of numbered, color-coded anvils cover all variations in assembly thickness. Change-over time is a matter of seconds.

E. G. Dyett, Jr., Purchasing Agent of H. H. Scott, reports, "The use of Thomson rivets and rivet-setting machines has produced assembly economies and resulted in lower over-all costs, while improving product appearance and mechanical construction."

Chances are the Thomson Fastening Man can help you improve product quality and reduce your costs. It costs nothing to find out. Make a date with him soon. You'll find him listed in the yellow pages of your phone book. In the meantime, you'll want Thomson's latest catalog. Write today for your free copy to Dept. MD.



Style 161
Thomson Automatic
Rivet-Setting Machine

JTL

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MFG. CO., WALTHAM 54, MASS.

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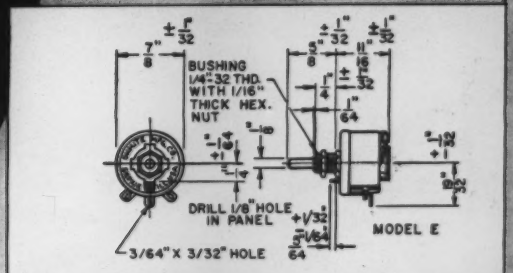
Newest addition to industry's most complete line of Rheostats

12½-Watt miniature OHMITE® Rheostat In Enclosure

Without enclosure, only ⅞" diam. In enclosure, exclusive of shaft but including terminals, only 1 7/32" long by 1 3/16" diam.

Compact enclosure of Model E Rheostat consisting of lightweight, drawn aluminum housing is dusttight.



Even though Ohmite already has the most complete line of rheostats available to industry, Ohmite continues research and development to *improve and expand* this product line. Newest addition is the 12½-watt miniature Model E Rheostat in enclosure. Ohmite's Model E wire-wound power rheostat will dissipate 12½ watts.* Yet, it is no larger than many 1- or 2-watt potentiometers. Such extraordinary power handling capability is characteristic of Ohmite's time-proven, all-ceramic and metal construction, and exclusive vitreous enamel coating. This tiny unit is designed to operate at a maximum hot spot temperature of 340°C. Derating is linear from full wattage at 40° C to zero watts at 340° C. With its small size, and because it can be used at high ambients, the Model E is applicable to *many military and aircraft uses.*

Special length shafts and bushings, screwdriver shafts, locking type bushing, tandem mountings, enclosures, etc., similar to the variations available on the larger rheostat, can be provided upon specific request.

* *Rating on metal panel*

Smaller than many 1- or 2-watt potentiometers

All-ceramic and metal—vitreous enameled

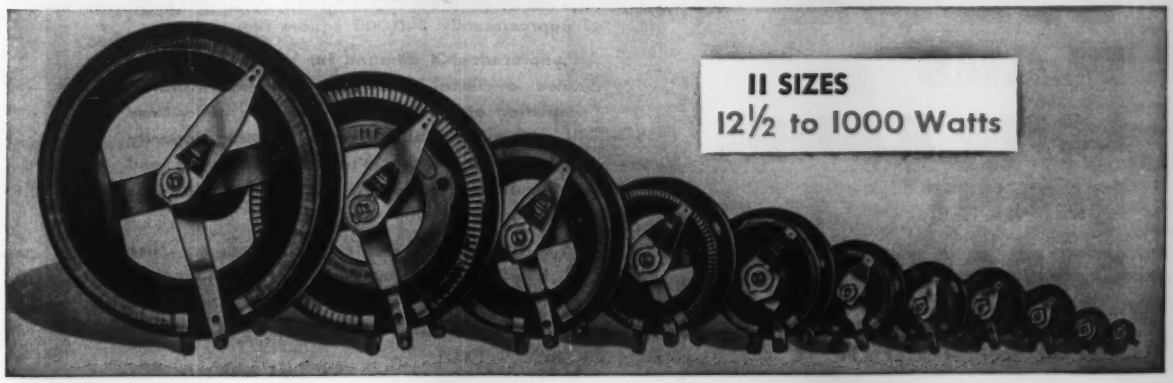
High dissipation for small size—many military applications

Tandem assemblies consisting of two, three or more units can be supplied made to order.

Resistance range: Up to 5000 ohms with 23 stock values; higher values available with OHMICONE silicone-ceramic coating.

Resistance Tolerance: ± 10%

Weight: 0.52 ounce



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rheostats tap switches resistors
r.f. chokes relays variable transformers
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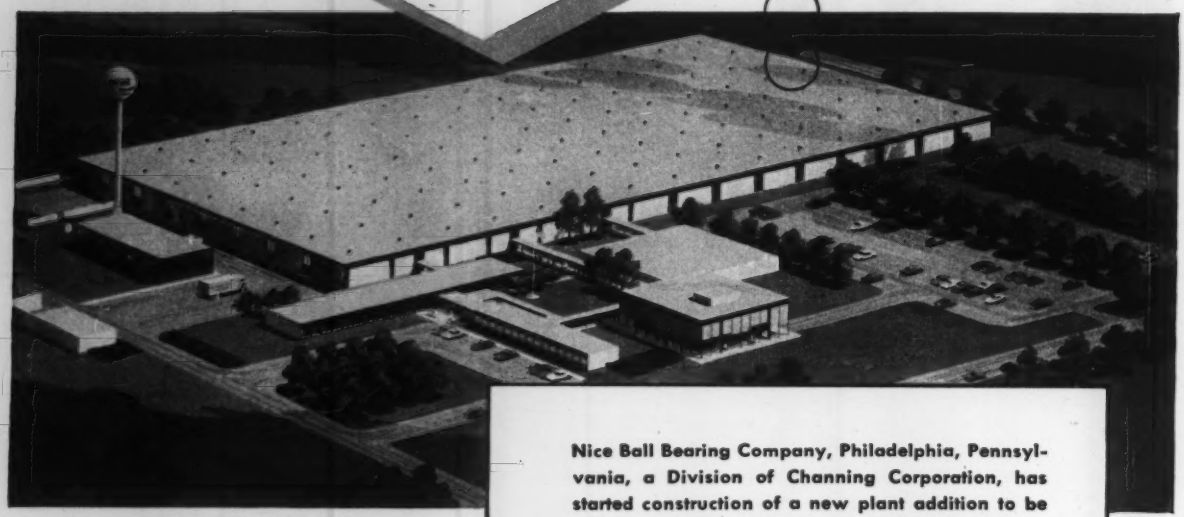
PREVIEW OF PROGRESS



NICE BALL BEARING COMPANY
Division of Channing Corporation
Towamencin Township, Montgomery County, Pa.

NICE PLANS LONG RANGE PLANT EXPANSION

First Unit to be Completed in 1959

Nice Ball Bearing Company, Philadelphia, Pennsylvania, a Division of Channing Corporation, has started construction of a new plant addition to be located in Montgomery County, Pennsylvania, approximately 30 miles north of the present Philadelphia plant. The first unit, scheduled for completion in 1959, represents Nice's fourth major expansion since the end of World War II and will provide approximately 40,000 square feet of additional manufacturing area. Future plans for the new location call for an ultimate completely integrated plant of approximately 340,000 square feet.

An unprecedented demand for Nice products has created a critical need for additional facilities. Completion of the new facilities now under way will add substantially to manufacturing capacity and will enable Nice to improve deliveries and provide better service to customers during the fourth quarter of this year.

One of the pioneers in the bearing industry, Nice Ball Bearing Company has been a nationally known manufacturer of ball bearings since 1902, producing bearings that are used in products throughout the world.

NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA
DIVISION OF CHANNING CORPORATION

Circle 442 on Page 19

zero plus

. . . and Carlson special stainless steels withstand the extremes of another launching

WHEN this missile "lifts off," Carlson special stainless steel plates help launch it into space. These plates are the high strength, precipitation-hardening grades. And there are sound reasons why these grades are used.

First, with Armco 17-4PH, 17-7PH and PH15-7 Mo* it is easier to attain the high physical properties and resistance to elevated temperatures required in space flight engineering. Simplified low temperature heat treatment will develop a Rockwell hardness of C40 to C50. Tensile strengths, so vital in missile components, range from 180,000 to 220,000 psi in plates.

Second, only Carlson produces these Armco grades in the heavier plate thicknesses. For applications where high strength at high temperatures and ease of fabrication are important, get plates in these grades from Carlson. We will be glad to work with you on specific applications.

*17-4PH, 17-7PH and PH15-7 Mo are trade marks of Armco Steel Corporation

G. O. CARLSON Inc.

Stainless Steels Exclusively

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District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES
FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

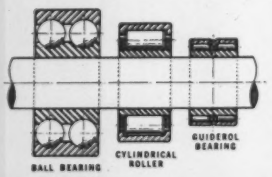
Photo of Atlas missile courtesy
CONVAIR ASTRONAUTICS,
A Division of General Dynamics Corp.

Circle 443 on Page 19

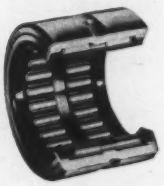
McGILL®

GUIDEROL® bearings offer higher load

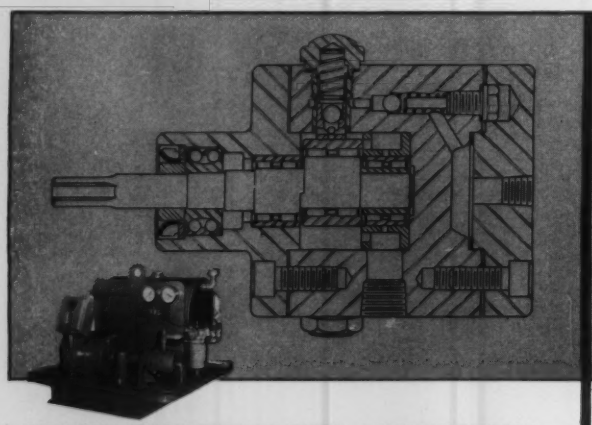
GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1" shaft, the GUIDEROL bearing has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅜" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance



Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

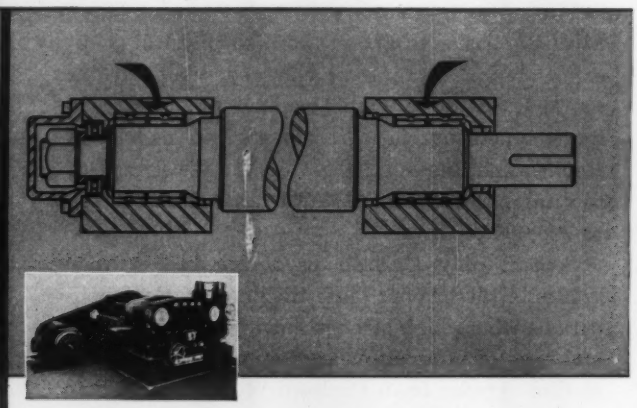


SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

McGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of McGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1" thick by 8" wide.

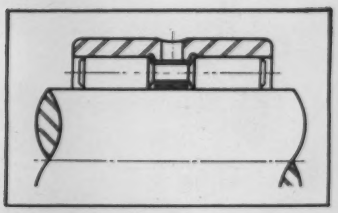
Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

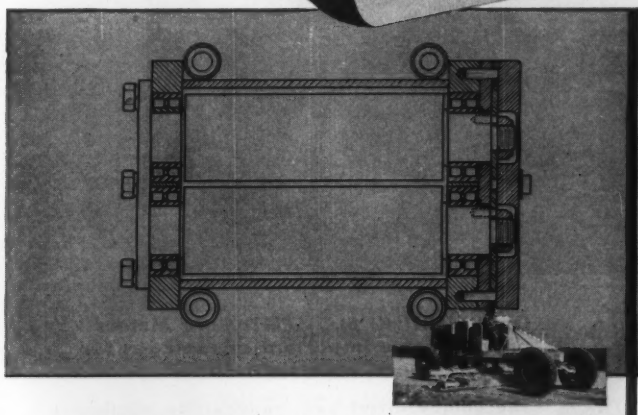
Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

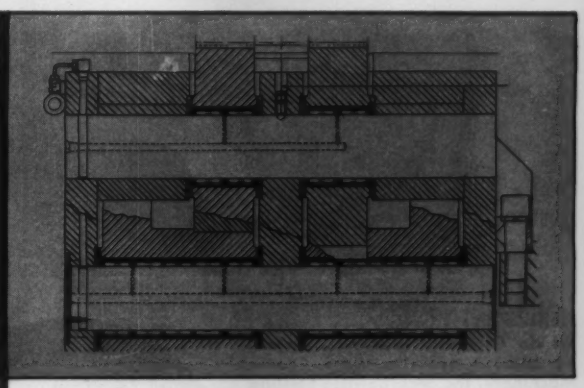
WRITE TODAY FOR FREE McGILL BEARING CATALOG No. 52-A for complete data on McGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

capacity in smaller radial space

GUIDEROL BEARING
Cutaway to show center guided roller principle







GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.

GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products

McGILL®

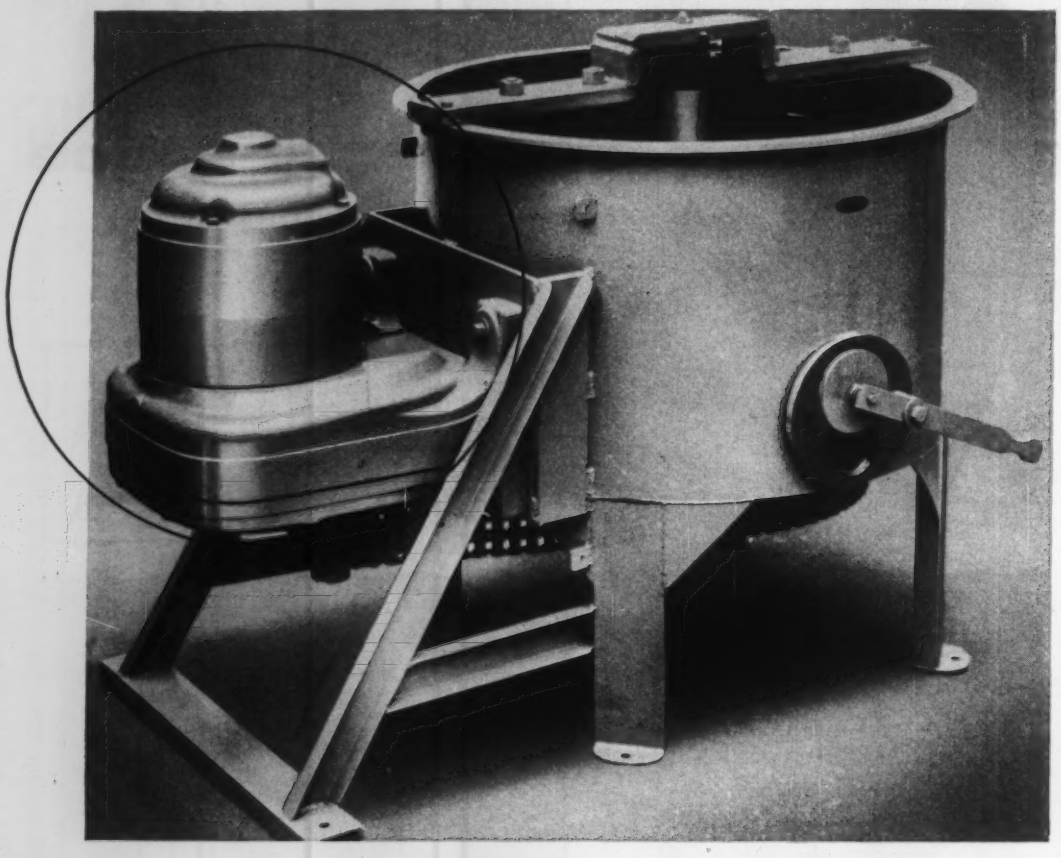
precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Div.,
200 N. Lafayette St., Valparaiso, Ind.

Circle 444 on Page 19

FOR SUBSTANTIAL SAVINGS IN MOUNTING SPACE... CROWN MACHINERY RELIES ON STERLING SLO-SPEED GEAR MOTORS!



HERE'S WHY!

As do so many leading original equipment manufacturers, Crown Machinery, Inc. incorporates Sterling Slo-Speed Gear Motors in its equipment used for chemical, paint and food applications.

Mr. Morris Cinaman, President, tells of the benefits resulting from the use of Sterling Slo-Speed Gear Motors with Crown units:

"Because of the compact design of the Sterling Slo-Speed Gear Motor, we have been able to save at least 10% in mounting space and to design our Crown Paste Mixer to take ratings from 5 to 15 horsepower. We are able to select the one best speed for each mixer's requirements. The positive oil seals, low maintenance, quiet operation and mounting adaptability make the Sterling Slo-Speed Gear Motor ideal for our machines. For these reasons, we can highly recommend these Sterling units."

Only STERLING SLO-SPEED Gear Motors provide these important advantages for efficient speed reduction:

- The unique offset gear construction eliminates wasted space. The more compact gear train design utilizes wider and larger diameter gears for greater strength and lower tooth pressure. The design of the gear case affords greater rigidity and strength.
- The tooth profile and helix angle of Sterling gears provide quiet operation and multiple-tooth contact with low thrust on bearings. Sterling helical gears, used in combination with heat-treated alloy steel pinions, insure maximum service life and trouble-free operation.
- Sterling positive oil seals keep oil in for maximum lubrication and leak-proof protection. Dirt and moisture are sealed out. Oil seals are impervious to chemical action of the lubricant.
- Sterling's oil sealing method and dip-splash lubrication permit universal mounting—vertically, *shaft up or down*, or in any horizontal position.

For additional information about the unmatched advantages of Sterling Slo-Speed Gear Motors for *your application*, please request a copy of Bulletin 191.

STERLING
ELECTRIC MOTORS, Inc.
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Offices and stocks in all principal cities. Over 400 distributors throughout the country to serve you.

NEW HYDRAULIC FLOW CONTROL VALVE

Calibrated for Precision Control

3/8" VALVE
Actual Size
$16.00

HANNA *Flo-Set 1000* VALVES

are used for controlling flow of petroleum liquids, water and synthetic hydraulic fluids.
Pressure to 1000 psi.
Sizes ¼", ⅜", ½" and ¾"
Temperatures –40° F to +250° F

To meet the demands for precision control of hydraulically powered equipment, Hanna offers this new calibrated speed control valve. Flow can be accurately regulated from zero to desired rate by turning the adjusting sleeve. Once set to the desired flow rate the valve can be "locked". Calibrations assist in setting the valve to pre-determined flow rates.

The new Flo-Set 1000 Valves are the result of over 50 years of Hanna design and manufacturing experience in the field of fluid power. They are built to close tolerances with quality materials and like all Hanna products they are offered only after extensive laboratory testing and field experience. Their performance is guaranteed for the service specified.

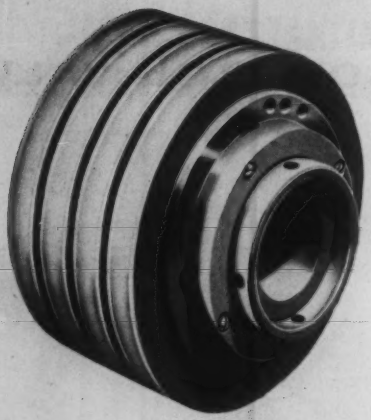
Ask your Hanna Representative listed in your classified directory and Thomas' Register for complete information—or write us for details.

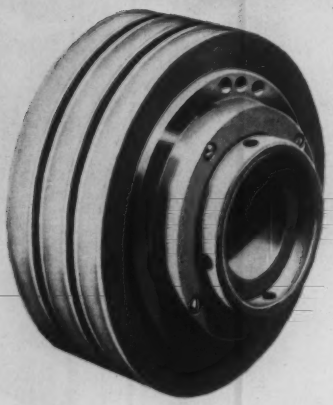
Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

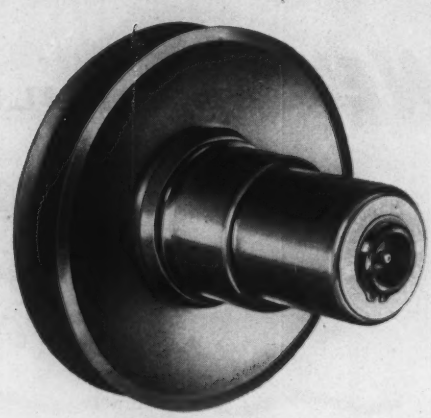
Circle 446 on Page 19

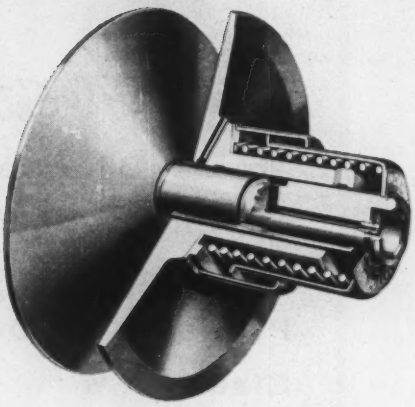




MULTI-PITCH SHEAVES. By adjusting movable flanges, you can provide larger or smaller pitch diameters on these multi-pitch sheaves. The adjustment can be made either when stationary (Stationary Control) or when in motion (Motion Control). They have a speed variation up to 2 to 1 on drives of from 1 to 600 hp. Motor bases are available to compensate for changes in center distances.

SPEED VARIATION 2:1



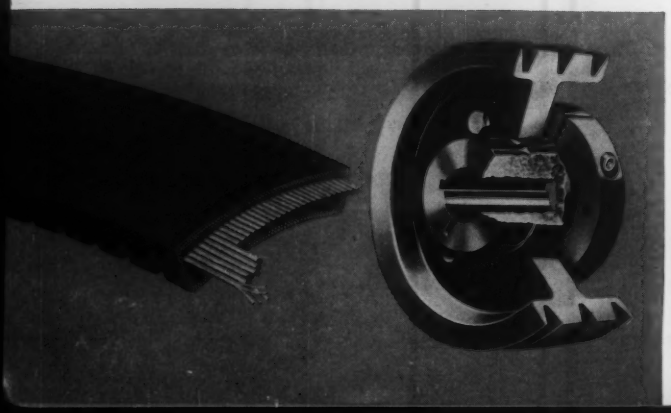


MOTOR PULLEY DRIVES. Worthington's new variable motor-pulley drives combine the efficient power transmission of a V to V drive with the industry's simplest motor-pulley designs for dependable low-cost power transmission with maximum hp. capacities. Ratios 3 to 1 hp. ratings ⅛ to 15. Angle-Matic motor base automatically maintains belt alignment and allows use of true V-groove companion sheave.

3:1

SOMEWHERE ON THIS LINE

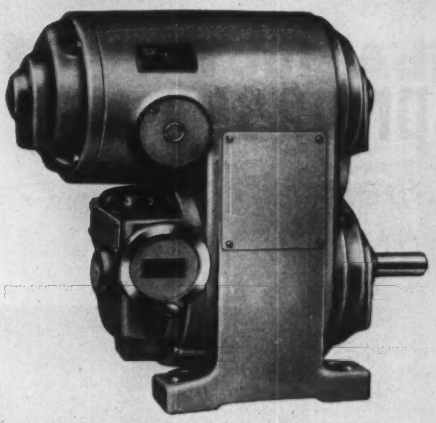
YOU'LL FIND THE ANSWER TO YOUR

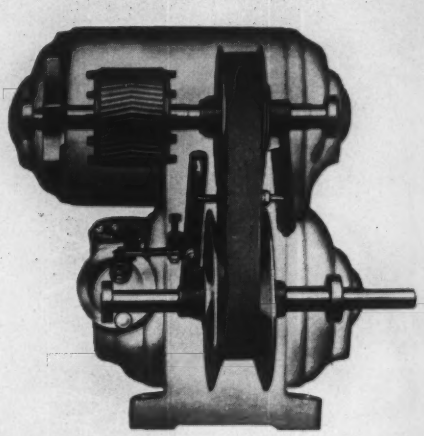


Sound V-belt engineering practice was used throughout Worthington's line of mechanical variable speed drives. They feature compact design, accurate speed control and long belt life.

The line consists of multi-pitch sheaves, motor pulley drives, motor drives, and allspeed drives which handle speed variations up to 20 to 1 and horsepowers from ⅛ to 600.

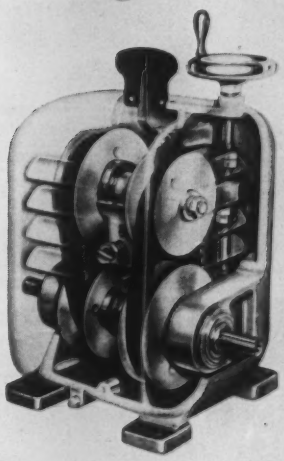
COMPANION SHEAVES AND VARIABLE SPEED BELTS are available from Worthington for use with multi-pitch sheaves and motor pulleys. All companion sheaves are equipped with the famous QD hub with the "Golden Screws." Oil-resistant, static-dissipating construction is standard for all Worthington variable speed belts.





MOTOR DRIVES. Positive pulley adjustment provides accurate speed control. Once you set the speed, the pulley holds it, regardless of varying load. Other benefits include: belt tension in proportion to load, giving extended belt life; compact design and transmission of full rated horsepower. Available in ratings from ½ through 25 hp. with speed variations up to 10:1.

10:1



ALLSPEED DRIVES. Not one, but two belts are used, resulting in an extremely compact unit. This "Twin-V-Tandem" design also gives a very wide speed variation (up to 20:1). Because of positive pulley adjustment, speed control is very accurate. Available in ratings from ⅓ through 5 hp.

20:1

VARIABLE SPEED PROBLEM

For more information about Worthington's complete line of variable speed drives, get in touch with your nearest Worthington representative or distributor. Or mail the coupon at right.

Circle 447 on Page 19

WORTHINGTON

WORTHINGTON CORPORATION
Section 79-16, Oil City, Pa.

Please send me your new catalogs on the following variable speed drive components:

- ☐ Multi-pitch Sheaves
- ☐ Motor Pulley Drives (1 to 15 hp.)
- ☐ Motor Pulley Drives (FHP)
- ☐ Motor Drives
- ☐ Allspeed Drives
- ☐ Variable Speed V-Belts

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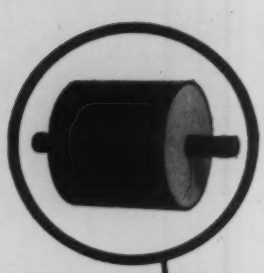
COMPANY_____

ADDRESS_____

CITY AND STATE_____



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new, low-cost suspension for trailers and light vehicles

Designers can gain cost and performance advantages by using Lord elastomeric springs on

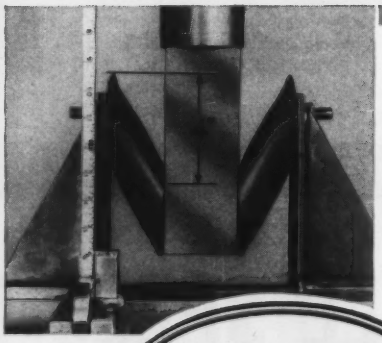
- boat trailers
- motorized scooters
- utility trailers
- baggage trailers
- ground handling equipment

Take the strength of steel and the long-wearing resilience of rubber. Bond them together permanently in a simplified assembly. The result: an elastomeric spring, today's most promising approach to suspension problems.

LORD elastomeric springs have superior characteristics which introduce vital savings in overall suspension. Shock absorbers are unnecessary due to inherent damping. Good stability characteristics eliminate lateral guide bars. Ease of attachment permits simpler supporting brackets, cuts assembly time and cost. Excellent service life is provided with no maintenance or lubrication required.

A safe, smooth ride is assured by high shock absorbing capacity and multi-directional cushioning. Light and compact, elastomeric springs also provide space savings, lower unsprung weight and a cleaner, more modern appearance.

LORD-designed elastomeric springs are used for thru-axle, individual wheel and dual-axle suspensions over a wide load range. Designers can obtain complete information from the nearest Lord Field Engineer or the Home Office, Erie, Pa.



High strength of elastomeric springs is demonstrated in load-deflection test. They provide greatest energy absorption for given weight and size.

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LORD MANUFACTURING COMPANY · ERIE, PA.

Circle 448 on Page 19

Solve Your Adjustable Speed Problems with this Combination

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DYNAMATIC®
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*AJUSTO-SPEDE®

If your problem is in the field of speed control, tension control, power transmission, or testing, Dynamatic Eddy-Current Equipment is the ideal solution. Dynamatic Ajusto-Spede Drives, Couplings, Brakes, and Dynamometers are solving these problems in virtually every industry—in both plant machinery and end product applications. Dynamatic equipment can do the same for you.

Ajusto-Spede Drives and other Dynamatic units offer the important advantages of rapid response, wide speed range, quiet operation, low power loss, low maintenance costs, and stepless adjustable speeds from an AC power source.

For complete information about Dynamatic problem-solving equipment, check with your local Eaton-Dynamatic representative or distributor.

The New Quill-Type Ajusto-Spede Drive provides controlled adjustable speeds for applications from ½ HP through 7½ HP. Together with the new K-2 Electronic Control and push-button station, this new Ajusto-Spede Drive comprises a compact, low-cost, 3-unit drive package.

Send for Illustrated Descriptive Literature Covering New Models ACM-903 and 904 Ajusto-Spede Drives

Red tint indicates adjustable speed member.

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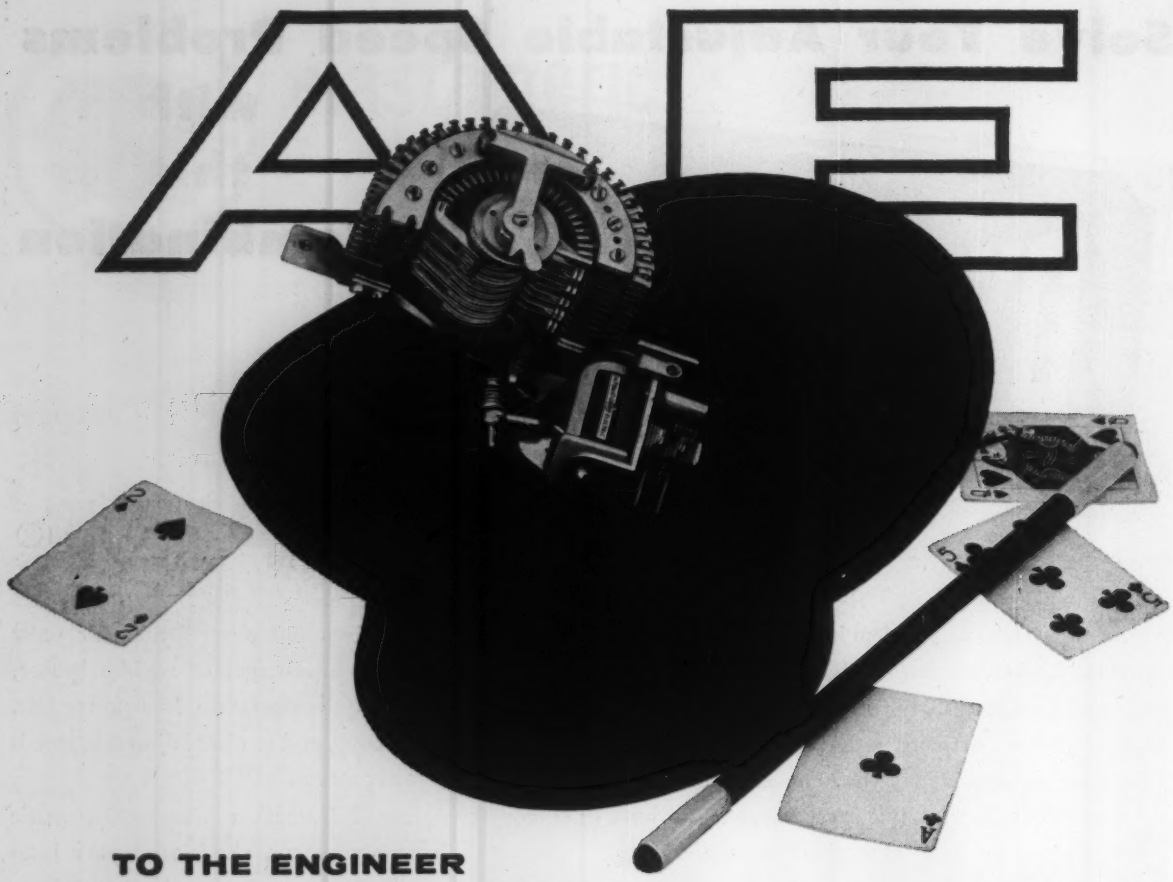


TO THE ENGINEER

who can use a little honest trickery

There's more than one way of skinning a cat —or making ideas *work* automatically. And AE has a bag-full.

That's because AE has had years of experience in making relays and stepping switches work wonders in automatic telephone exchanges—*and* in automatic control devices.

If you can use some down-to-earth magic in your designs, AE engineers will be glad to help. And you may well find that their suggestions can simplify the control package.

They can also show you why AE relays and stepping switches cost you less in the long run.

For instance, the AE Type 45 Stepping Switch, illustrated, has a free-floating pawl that never binds, never breaks, eliminates the necessity of ever readjusting armature stroke, does away with double-stepping or overthrow. And the switch usually outlasts the equipment it's built into!

You'll also be interested in knowing that AE is equipped to deliver completely wired and assembled control units designed to your specifications.

Want more information? Just write the Director, Industrial Products Engineering, Automatic Electric, Northlake, Illinois. Ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

Circle 450 on Page 19

the **neg'ator® *sketchbook***

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

LONG-RUNNING, CONSTANT-TORQUE NEG'ATOR® MOTORS SOLVE COMPLEX "MECHANICAL DRIVE" PROBLEMS

The engineer who includes NEG'ATOR springs in his design thinking has, ready for use, a device with remarkable and never-before-obtainable properties. This is particularly true in the field of mechanical drives where *long-running, constant-torque, space-saving* NEG'ATOR motors have solved difficult and often close-to-impossible problems.

At present, three types of NEG'ATOR motors are being used to obtain a wide range of torque ratings. These include the single-band motor, the multiple-band type, and the SPIR'ATOR motor which is a derivative of the NEG'ATOR spring. These types are shown in Fig. 1.

Following are several examples of how NEG'ATOR drive units are being applied in differing mechanisms. Other applications are described in previous Sketchbooks, copies of which are available on request.

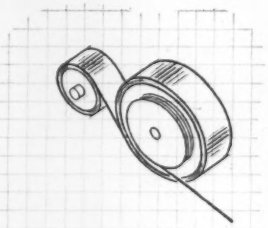


FIG. 1A. A single-band NEG'ATOR motor is made by mounting a NEG'ATOR spring on a take-up drum and then reverse-bending the free end around a larger, output drum. The tendency of the material to recurl to its preset curvature around the smaller drum imparts desired torque to the shaft of the output drum.

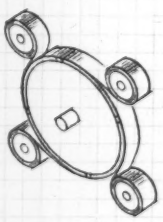


FIG. 1B. To obtain higher torque ratings and long cycle life, a multiple-type motor can be made as shown. In this case, the ends of four NEG'ATOR springs are attached to a common output drum.

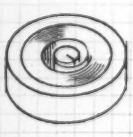
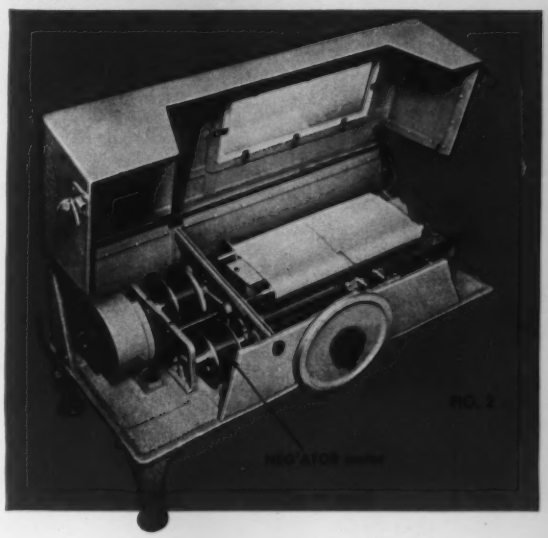


FIG. 1C. The SPIR'ATOR motor consists of a NEG'ATOR spring, reverse wound on an arbor inside a case. In appearance, this unit resembles a conventional power spring. Unlike a power spring, however, the SPIR'ATOR is capable of low torque gradient, longer run, and higher starting torque, using thinner material.

LONG-RUNNING SPRING MOTOR DRIVES INSTRUMENT CHART 4½ MONTHS



Engineers at Leupold & Stevens Instruments, Inc., in Portland, Oregon, used a NEG'ATOR motor in their Type A35 Water Level Recorder and, by so doing, made the unit self-contained, lighter in weight, and simpler in design.

They designed a NEG'ATOR motor using a $3\frac{1}{16}$ in. diameter output bushing, a $1\frac{27}{32}$ in. diameter take up (storage) bushing and a NEG'ATOR spring made from material .014 in. thick and $1\frac{1}{4}$ in. wide. This motor was mounted in the recorder as shown in Fig. 2.

Because the torque output of the NEG'ATOR motor remains constant at 17 lb.-in. throughout rundown, the speed of the motor, and the rate of advance of the recorder chart, can be regulated precisely by the marine-movement clock mechanism of the recorder. The rate at which the chart is driven can be adjusted in standard increments ranging from 1.2 to 9.6 in. per day by changing the time-scale gearing between the clock mechanism and the NEG'ATOR motor. At the speed normally used, the recorder operates continuously for $4\frac{1}{2}$ months without rewinding.

Engineering ingenuity in this case resulted in long running time, far greater portability, design simplification and lower manufacturing and installation cost. In addition, the recorders can be more completely sealed from dirt and moisture.

PUBLISHED BY HUNTER SPRING COMPANY • LANSDALE, PENNSYLVANIA

A Division of American Machine and Metals, Inc.

For an additional copy of this sketchbook Circle 451 on Page 19

CONSTANT TORQUE IS IMPORTANT IN ELECTRICAL TIMER APPLICATION

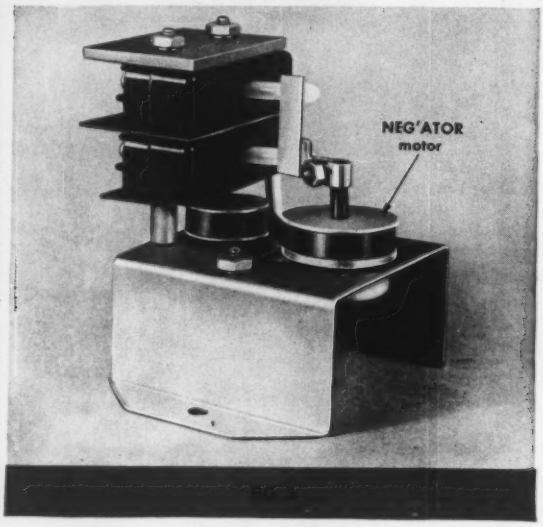
The electrical delay timer shown in Fig. 3 illustrates how important the constant-torque characteristic of a NEG'ATOR motor can be in certain applications.

The timer used an electric timing motor to control the actual time delay interval. Finding a simple mechanical motor to properly reset the timer presented a major problem.

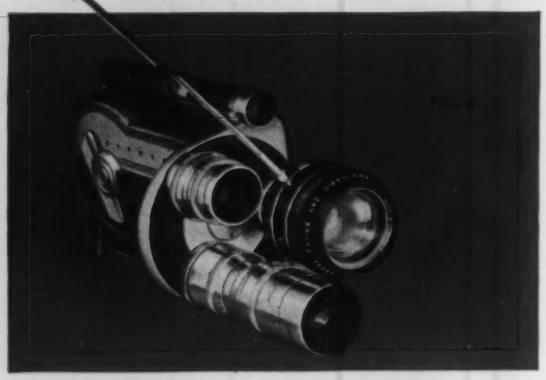
Specifications called for a mechanical spring motor to reset the timer in not less than 3 and not more than 9 seconds. Haydon engineers first considered a conventional clock spring. However, a clock spring capable of delivering the 2 oz. force required to trip a switch at rundown operated too fast. One which operated within the specified time limits couldn't produce enough power to trip switches at rundown.

The small NEG'ATOR constant-torque motor shown in Fig. 3 solved the problem. The constant output torque of this motor provided sufficient force for tripping switches even at full rundown at a controlled reset time of 4.5 seconds, well within specifications.

The particular timer illustrated is a protective device designed and manufactured by Haydon Manufacturing Co. for use in connection with electronic instruments. The basic design, however, is easily adaptable to any timer requiring a predictable reset time.



SPACE SAVING IS KEY CHARACTERISTIC IN CAMERA ACCESSORY APPLICATION



The attachment on the lens of the movie camera in Fig. 4 is the first mechanical Fading and Dissolving Device ever made for hand-held motion picture cameras. By rotating one of two polarizing filters through 90 degrees, the device fades or dissolves the camera picture.

Engineers of Wollensak Optical Company who developed this Fading and Dissolving Device considered using a conventional power or clock spring as a drive to rotate the one filter. However, initial investigation established the rough dimension for the spring arbor and restraining ring at 1½ in. and 2 in. respectively. Minimum material thickness required to satisfy normal design stress requirements would have been .06 in.—obviously impractical. Thinner material would have resulted in an inefficient spring with insufficient useful energy.

The solution proved to be a NEG'ATOR motor derivative called a SPIR'ATOR motor. See sketches, Fig. 1C and Fig. 5. This stainless steel drive spring is .007 in. thick and 5/16 in. wide. It is mounted on a 1.430 in. O.D. arbor and is restrained within a 1.930 I.D. ring. It delivers a minimum of 2½ useful turns with output torque level enough to be easily controlled and to provide even fade-out and fade-in. Five dissolves can be made with one winding.

Thus, the "small space" requirement was met by the SPIR'ATOR motor with close-to-constant output torque and long run as bonus benefits.

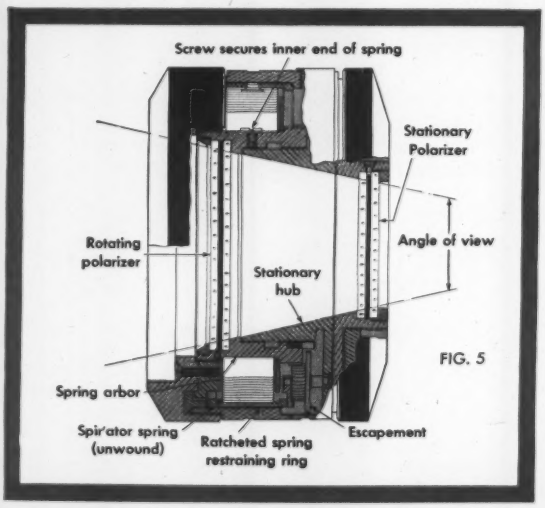


FIG. 5

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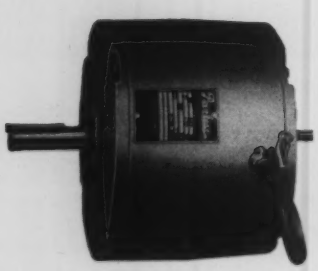
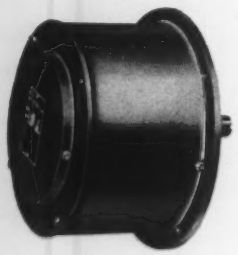
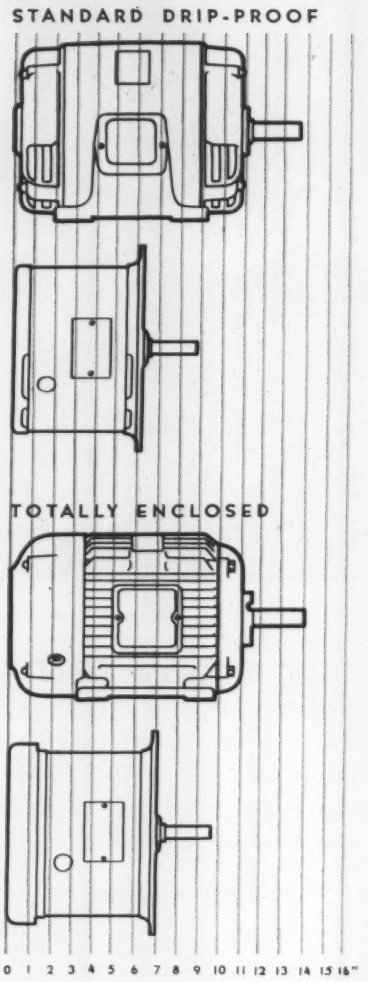
WHEN YOU NEED MORE MOTOR IN LESS SPACE

If your problem is how to put more motor in less space, this Peerless Space-Saver may be the answer. The line includes both drip-proof and totally enclosed designs in ratings from ½ to 10 HP. Bearings are pre-lubricated, double-shielded type. Peerless will work with you to build in any special requirements—torque, mounting, enclosure, duty, or insulation. Peerless Space-Savers cataloged in Bulletin SP-1 meet all NEMA performance standards.

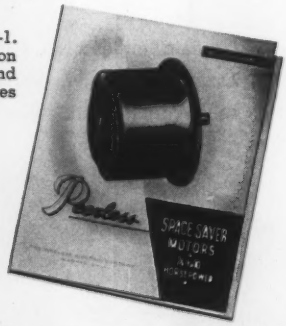
Peerless is a specialist in OEM applications. Close cooperation with your engineers assures the development or selection of the one motor that powers your product. There's a Peerless sales engineer near you. If you don't know him, write to Peerless.







WRITE FOR Bulletin SP-1. It gives complete data on Peerless Space-Savers and lists nearby Peerless sales engineers.



ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

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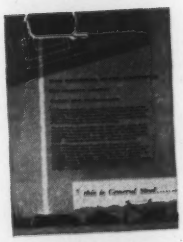

Write for folder: **How General Steel Castings Can Improve Product Design and Performance.** General Steel Castings, Station 260 Granite City, Illinois.

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Circle 454 on Page 19

Francis E. Blod specifies

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for the kitchen of tomorrow . . .

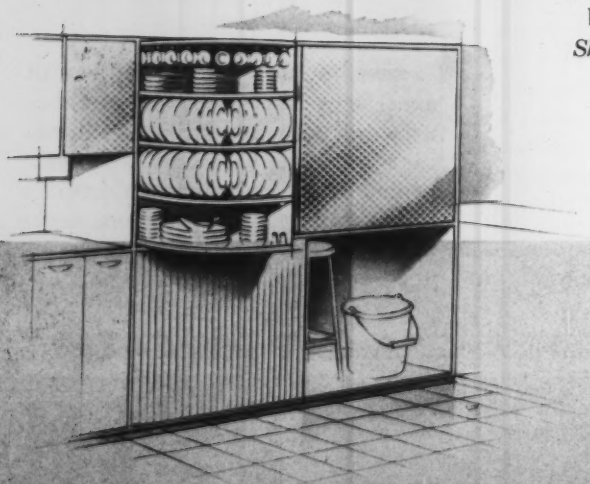
To give kitchen storage added utility and exciting style that blends with modern day kitchen appliances, nationally known industrial designer Francis Blod has taken advantage of Sharonart, to achieve the clean line, functional and highly attractive kitchen storage unit shown on these pages.*

A recipient of many national design awards, Mr. Blod is a Board Member and President Emeritus of the Package Designers Council; graduate and member of the Board of Trustees of the School of Design of Pratt Institute.

Sharonart*, Sharon's exciting new surface patterned steel, is stimulating the imaginations of leading designers everywhere.

It has all the strength, economy and forming advantages of steel, plus the mar resistance and added beauty of a textured surface. Ideal for wear areas, it permits model changing without retooling. Available in dozens of patterns, Sharonart* can be made in almost any special pattern to suit design requirements. Patterns are rolled in plain carbon steel or in stainless steel. Literature and samples available upon request from the Sharon representative in your area by writing direct to the *Sharon Steel Corporation, Sharon, Pa.*

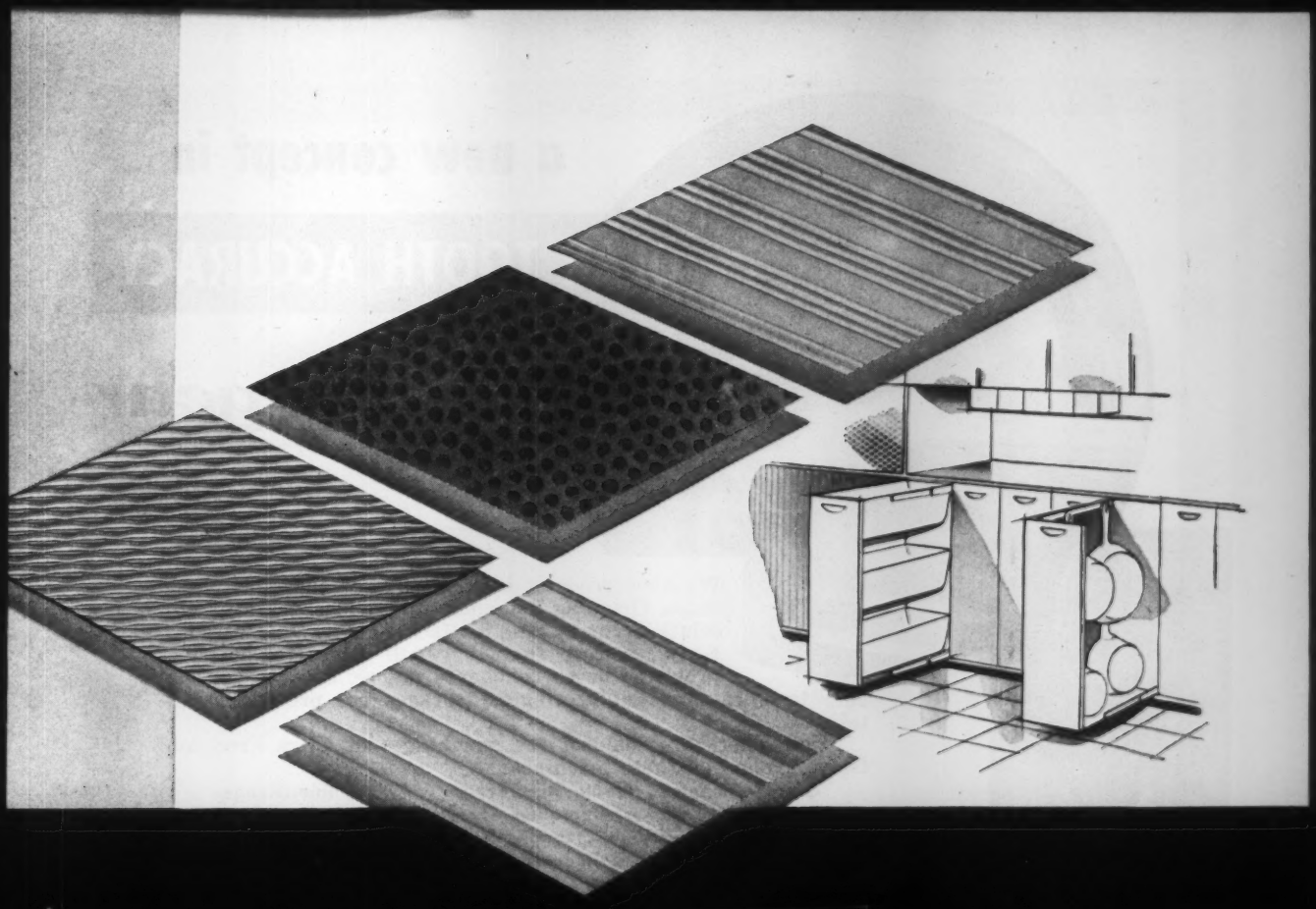
*TM



Rotating cupboard accomodates both dishes and glassware providing organization and ready access while preventing chipping. Sliding Sharonart panel utility section provides storage for outsized objects.*

Pull-out bins offer ready accessibility to staple vegetables as well as pots and pans. Protruding handles are eliminated through the use of pressure sensitive spring loaded closures and recessed pulls.

Trim look of Blod designed kitchen unit includes flatware and linen drawers and automatic Sharonart stainless steel canisters adjusted to dispense premeasured amounts of dry foods, spices, etc.*



SHARON *Quality* **STEEL** SHARONSTEEL

Circle 456 on Page 19

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Single point grinding method eliminates burning or cracking of tooth surface

We have recently installed five of the latest Precision Grinding Machines to produce gears of absolute accuracy and surface finish . . . Gears so truly accurate that they will solve transmission problems never conquered before, because you secure technical and engineering advantages not previously obtainable.

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Of course, we have only "touched the surface" in this advertisement, but if you get in touch with us, we will give you complete information about this Ultra Precision Gearing . . . No obligation.

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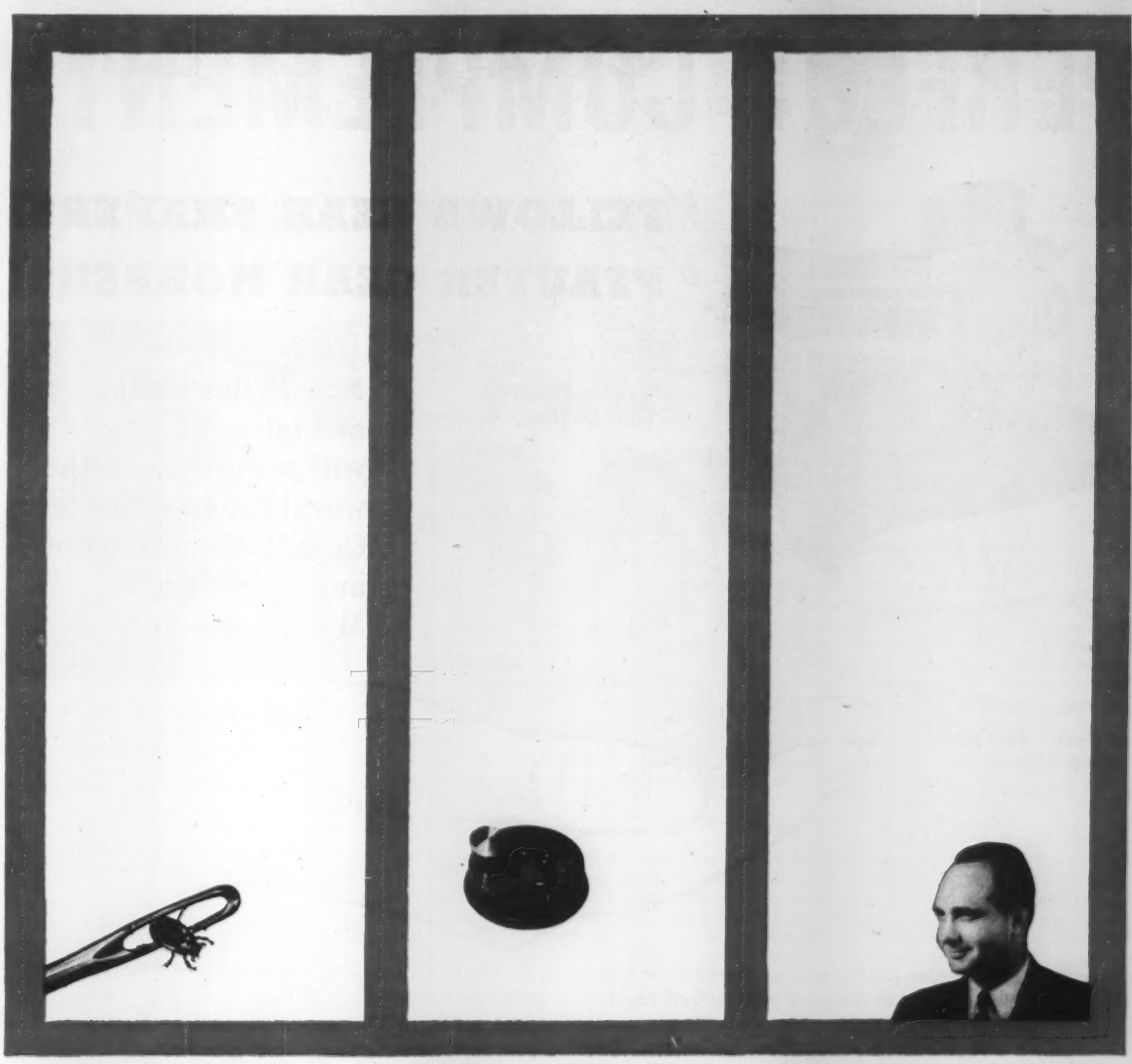

Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.

Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Dean Skillin makes a practice of showing people how small, precision-made MPB bearings reduce maintenance, increase economy, and solve miniaturization problems. He's ready to do the same for you.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN TAPE RECORDER SHOWN ABOVE

Little Things That Count. There's nothing new, in the larger sense, about ball bearings. But miniaturization of these familiar components is a wholly modern development. Forty years ago, for example, MPB was first to manufacture bearings with O.D.'s as small as 3/8", and with precision that brought new aid to science and industry. Today, after continual pioneering in miniaturization, MPB produces over 500 types and sizes of bearings, ranging down to 1/10" O.D., with specials as required. Our catalog brings you details on these bearings. Write for it, or for engineering advice, to **Miniature Precision Bearings, Inc.**, 107 Precision Park, Keene, N.H.

MINIATURE PRECISION

MPB

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Pfauter P 400 Gear Hobbing Machine

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Fellows Gear Shapers and Pfauter Gear Hobbers provide complete coverage of modern gear production equipment needs. Both operate on the molding-generating principle. The Pfauter Hobbers embody every important advance in hobbing technique, in most cases originated by Pfauter. And Fellows Gear Shapers incorporate every major advance in gear production by the Gear Shaper method originated by Fellows.

Among the many features incorporated in Pfauter Hobbers are the differential for helical gear hobbing, the hydraulic backlash eliminator for efficient climb hobbing, the fully automatic plunge for longitudinal and radial-tangential hobbing and, most recently, exclusive Pfauter DIAGONal Hobbing. Capacities of Pfauter machines range from 3" max. P. D., 2¾" max. face width, to 120" max. P. D., 1¼ D. P., and 30" max. face width.

With the addition of the Pfauter line, Fellows provides the most comprehensive service possible in the field of gear production equipment. Your Fellows representative can give you full information about our machines and instruments which cover every phase of gear production.

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THE PRECISION LINE *Fellows* *Gear Production Equipment*

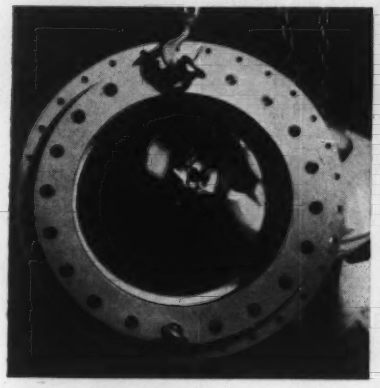
Circle 459 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NEW PICTURE WINDOWS FOR NAVY'S NUCLEAR REACTORS

In the "older" models of the Navy's nuclear subs, a periscope was used for checking reactor operation.



Not so in today's subs. Now you'll find giant peepholes—windows that let you look directly into nuclear compartments.

These windows are made from a combination of Corning high-lead-content glass and a plastic. The latter shields against neutron bombardment. The high density *glass* (6.2 cc, the equal of iron for shielding) protects against gamma rays.

Just for the record, seagoing radiation windows are only one part of a rather extensive line that Corning makes.

To date, for example, we've handled the shielding window problems of some 200 "hot" cells. Such windows often approach Gargantuan proportions . . . like the five-foot-thick, nine-ton job we finished recently.

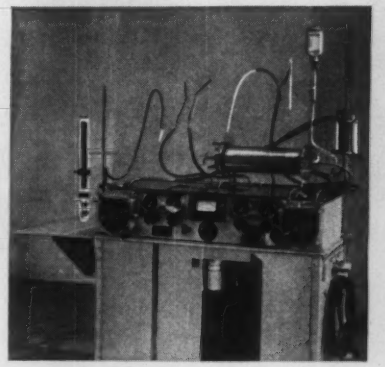
The big advantage for you, the user, in all this . . . aside from the fact that you can get any combination of three very special glasses we make for shielding . . . is *simplicity*. You just tell us your energy level, wall thickness, and the viewing area you need. We do the rest . . . ship you a window that's *ready to install*. It's as easy as that.

Added incentive: The most recent design change we've come up with involves a more pronounced *taper* than was previously used. This makes for less weight, easier installation, better fit.

Delve further into this subject by checking the box in the coupon, labeled "Radiation Shielding Windows." This will bring you a detailed booklet. Or drop a note outlining what's on your mind to Plant Equipment Sales Department.

THE HEART OF THE MATTER

During certain operations involving the heart, both the heart and lungs are given a rest.



But the functions of these organs still must go on. So ingenious machines take over. Like the Kay-Cross rotating disc oxygenator that does the work of the lungs, controlling the CO_2 and putting in pure oxygen.

The main component of this oxygenator is a series of discs, so designed that blood spreads out without foaming or bubbling.

Comes the commercial. These metal discs must be enclosed in a container. And the people who make the oxygenator, Pemco, Inc., chose a PYREX brand glass to hold the discs.

For good reasons. First off, this PYREX brand glass lets you keep careful watch over the *color* and *flow* of the blood, both very vital considerations to the medical men who use this machine.

Then, this PYREX brand glass is *inert* chemically. It does not add to or take from the blood in any way. There is no pickup, no side effects.

And, because this glass has a low coefficient of thermal expansion, 32 x 10^{-7}in/in/°C., the entire machine can be steam sterilized *without* any fear of danger from thermal shock.

While this particular application may be far afield from your work, one of the PYREX brand glasses may still turn out to be the answer to one of the tough design problems you are now facing.

You'll find that this transparent, corrosion- and thermal-shock-resistant glass is available in rod, tubing and flat glass. And it can be worked into a wide variety of special shapes by automatic pressing and blowing machinery.

Perhaps the best approach for you is to avail yourself of two well-detailed reference folders, B-83, "Properties of Selected Commercial Glasses," and IZ-1, "Designing with Glass for Industrial, Commercial and Consumer Applications." Use the coupon.

YOU CAN MAKE GLASS BREAK THE WAY YOU WANT WHEN YOU WANT

Tempered glass breaks in a very special way—we call it "dicing"—and that has led to some very special uses:

Rupture discs—Say you're holding a liquid or a gas in a container and at some precise moment you want to release it suddenly and smoothly. You can insert a tempered glass disc in your container, a disc that has been prepared to disintegrate at a given pressure.

The pressure can be applied by the fluid or by a small charge attached to the disc. When you want it to go, the glass will shatter instantaneously and homogeneously into small pieces.

Probable uses for this include safety valves on process equipment and as a substitute for intricate valving on fuel injection systems. Using PYREX brand Glass No. 7740, you can cross corrosion off as an inhibiting factor on valves. Pressure ranges run from 100 to 1000 psi.

Metal samples and billiard balls—Glass is also being used in the form of tubes to remove samples from molten metals . . . the glass crazes but holds together long enough for your sample to cool into a smooth cast; then you strip off the glass and you're ready for analysis. The plastics people are using glass molds where they want smooth surfaces . . . billiard balls, for example; when the plastic cools you just chip away the glass.

Want glass that breaks how and when you want it? Write to our Industrial Components Sales Department, spelling out your problem.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52-7 Crystal Street, Corning, N.Y.

Please send me: ☐ "Radiation Shielding Windows"; ☐ Bulletin B-83; ☐ Bulletin IZ-1

Name_____ Title_____

Company_____

Street_____

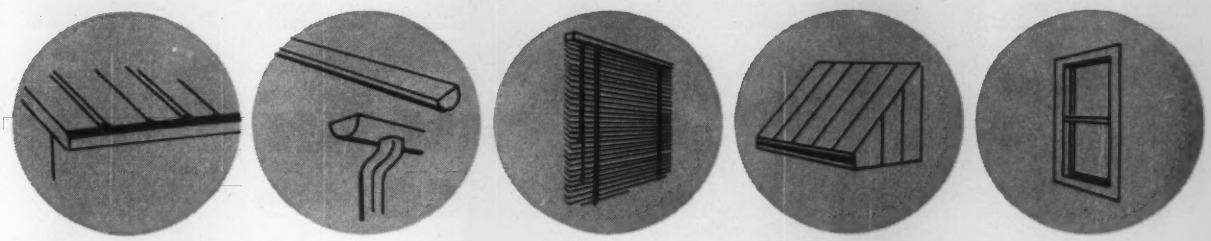
City_____ Zone____ State_____

Circle 460 on Page 19

Photo courtesy LITHO-STRIP CORPORATION, Chicago, Ill.

BONDERIZED ALUMINUM

makes your painted products look better longer



Most famous of all surface treatments for metals—BONDERITE—makes painted aluminum look better longer.

Bonderite on aluminum means fine appearance longer, because it controls corrosion and anchors the paint.

Bonderized and painted aluminum is produced on automated strip lines in which the metal is cleaned, Bonderized and painted, then re-coiled ready for use.

Stamped or roll-formed products are made from pre-painted, Bonderized aluminum coil without loss of paint adhesion, even from the most severe deformation. Here's production efficiency and economy at its best—better products at less cost.

Many Applications of Bonderite for Aluminum

There's more than one type of Bonderite for use on aluminum. In wide use is Bonderite as a base for paint, which adds durability and long life to paint finishes on so many aluminum products.

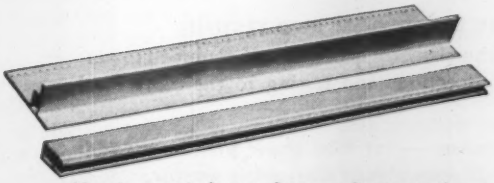
Another Bonderite produces an attractive green coating, used on many architectural products without further finish.

Protection without changing the characteristic color of the metal is provided by another Bonderite.

There is also a Bonderite, formulated for mixed production, which coats aluminum, steel and zinc.

Bonderite for aluminum meets and exceeds the requirements of Government Specification MIL-C-5541.

Well over two hundred plants—large, medium-sized and small—use these great Parker products on their aluminum production. Better investigate for *your* plant, today!



Aluminum window and screen frame sections Bonderized, painted and formed after painting. No breaks in finish anywhere! (Courtesy, Security Co., Detroit, Mich.)

SEND FOR ILLUSTRATED BULLETIN!—*Free bulletin, with more complete information and details, mailed immediately upon request. Ask for Bulletin A6790, "Bonderite for Aluminum."*

Parker Rust Proof Company

2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

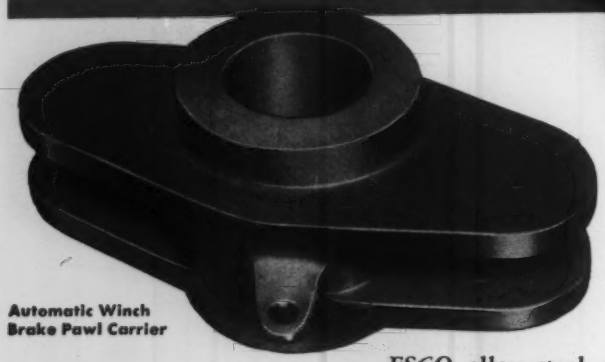
BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

BEFORE YOU SAY

"IT CAN'T BE CAST"

Transmission Shifter Fork



Automatic Winch Brake Pawl Carrier

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ESCO alloy steel castings can make your designing *easier*. You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time.

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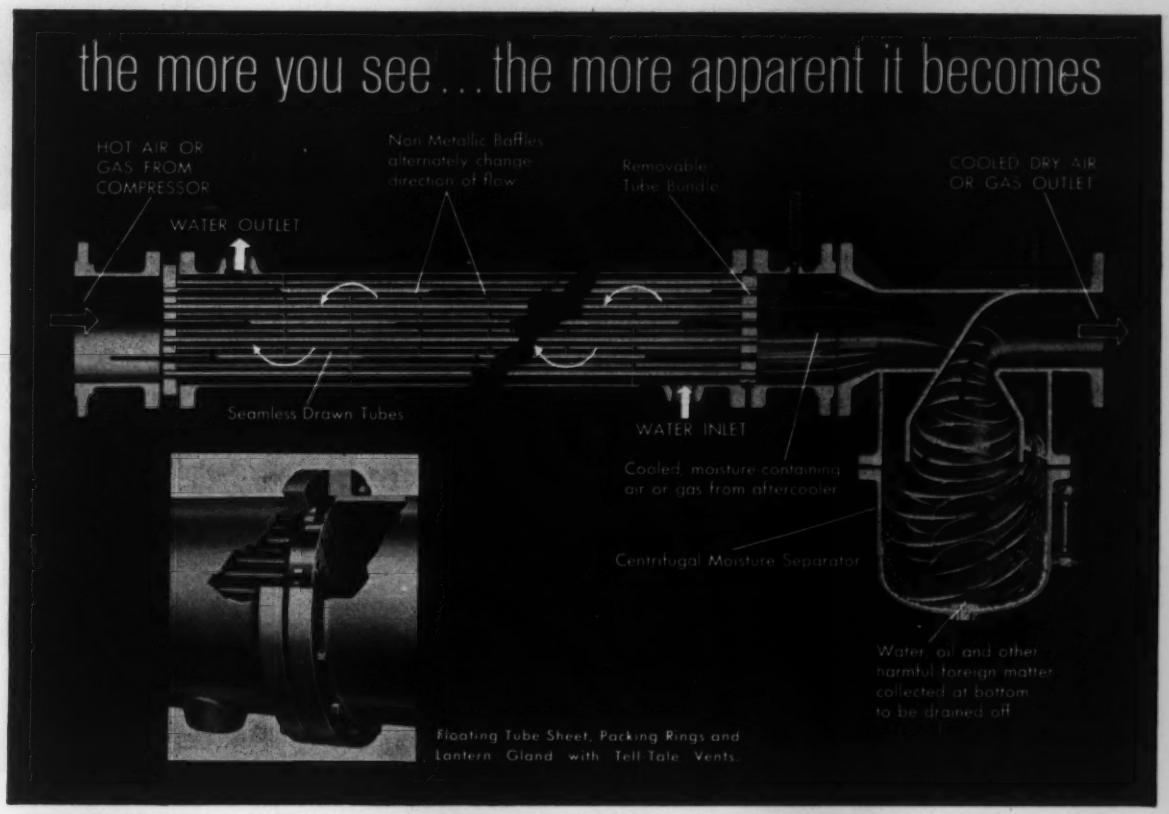
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HOT AIR OR GAS FROM COMPRESSOR
WATER OUTLET
Non-Metallic Baffles alternately change direction of flow
Removable Tube Bundle
COOLED DRY AIR OR GAS OUTLET
Seamless Drawn Tubes
WATER INLET
Cooled, moisture containing air or gas from aftercooler
Centrifugal Moisture Separator
Water, oil and other harmful foreign matter collected at bottom to be drained off
Floating Tube Sheet, Packing Rings and Lantern Gland with Tell Tale Vents

NEW ROSS PIPELINE AFTERCOOLERS

are today's most effective means of cooling and drying compressed air

Here, cut away for your inspection, is the new Ross Type A-100 Pipeline Aftercooler . . . the "inside story" with everything revealed.

Note how the air in the tubes flows counter to the water in the shell so that the coldest (incoming) water serves the coldest (outgoing) air. Note, too, how the air is baffled into a swirling eddy within the moisture separator to force (centrifugally) water and all other entrainment from the line.

Examine every feature! The more you see, the more apparent it becomes: *This new aftercooler is the most efficient unit ever built for air compressor service.*

Equally important is the fact that fully standardized parts are utilized to eliminate costly "specials" in both engineering and fabrication. You save in every way.

Compact and easy to install, a Ross A-100 can be readily fitted into any compressed air system. There are 54 models to choose from, with capacities ranging from 0 to 36,000 scfm at operating pressures up to 150 psig for single or two stage compression.

Why not see all there is to see? New Bulletin 302.6K1 contains the complete, illustrated story as well as specifications. Send the coupon for your copy now.

Mail this coupon for new Bulletin

TO

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Industrial Division
Detroit 32, Mich.

SEND your new Bulletin 302.6K1 describing Ross Type A-100 Pipeline Aftercoolers.

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Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

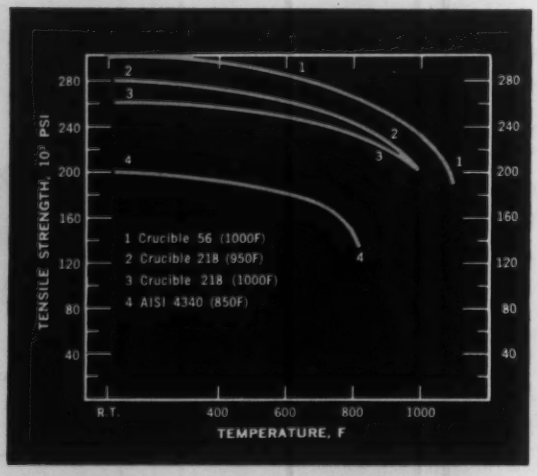


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

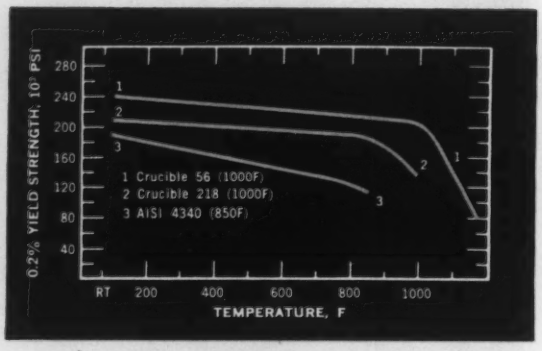


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

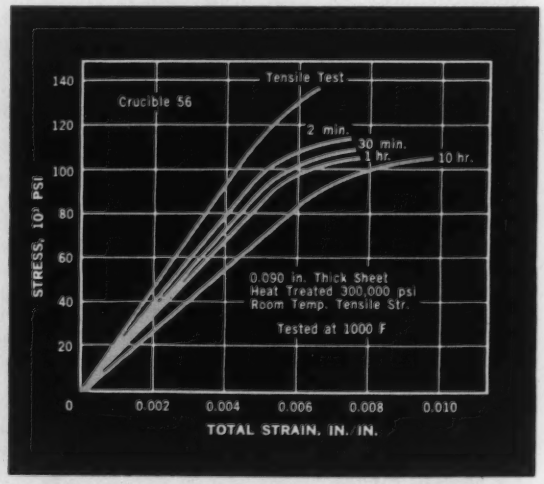


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

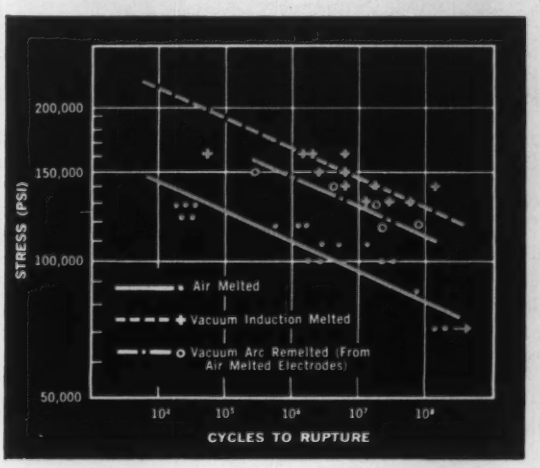
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	< 1
AM+VAR	7	70	< 1
VIM	5	3	< 1
VIM+VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EG07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

Company_____

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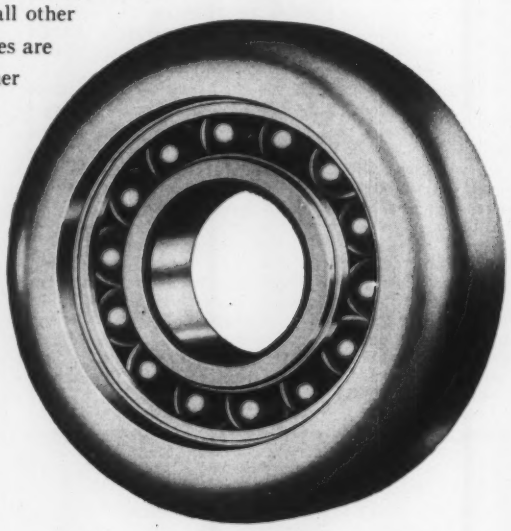
CRUCIBLE STEEL COMPANY OF AMERICA

Circle 464 on Page 19

For Endurance . . .

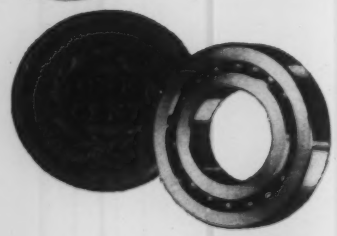
It's the NEW HEIM *Unibal*® Ball Bearing

Simplified construction and an entirely new method of ball bearing manufacture represents a great stride forward in anti-friction bearing design. A solid outer race with deep, continuous, unbroken ball groove; and a solid inner raceway with matching ball groove made to fit around a full complement of balls. This eliminates the necessity for loading slots, split raceways, separators, and all other extra and costly assembly devices. The ball grooves are burnished, deep carburized, and hardened. The inner and outer raceways are machined to a smooth finish; the result is quiet, smooth operation, longer bearing life, greater load capacities, and lower costs.



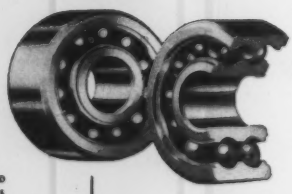
The design possibilities in this new Heim method of construction are almost unlimited. One example is this 4″ heavy duty bearing for high radial and axial load conditions.

Bearings with plain outer members in small sizes.

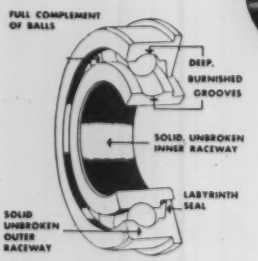


. . Medium sizes or sizes to 2″ diameter and over

Bearings with flanged outer members in all sizes



Double row type bearings.



Send for bulletin UBB showing stock sizes and capacities, or ask about special applications.

Manufactured by THE HEIM COMPANY
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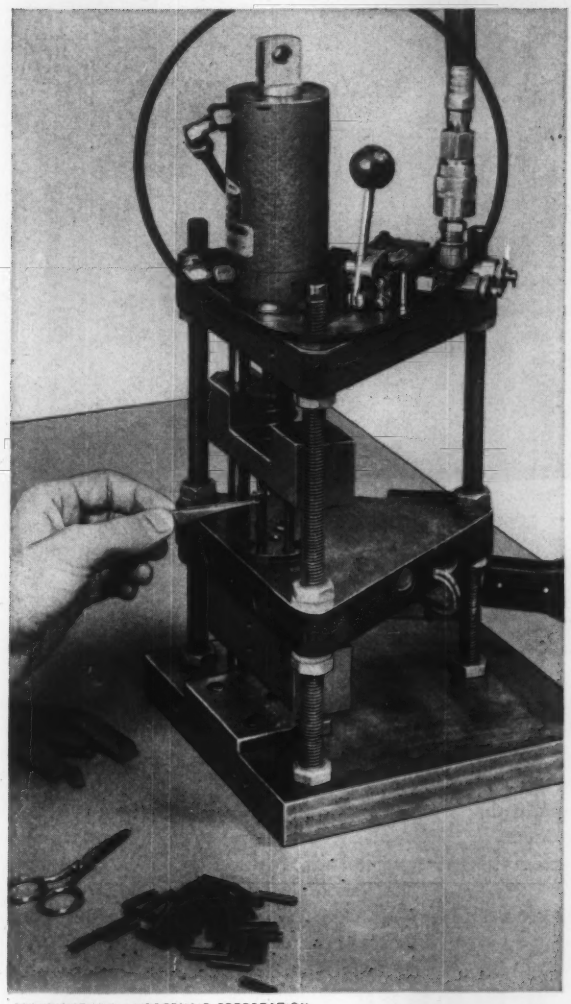
Automate for profit now with Modernair®



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ULTRONIX, INC. builds its own Modernair-powered plastics molding presses

Manufacturers of precision wire-wound resistors for the fast-moving electronics industry, ULTRONIX, INC., had to develop much of their own production equipment for their new plant at San Mateo, Calif.

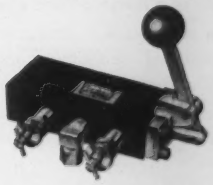
Typical is the molding press shown here which turns out a tiny plastic bobbin for their "ULTRIMMER" miniature trimming resistor.

A 2" bore double-acting Economair cylinder with 5" stroke closes the electrically heated molding die, holds it under pressure for the 45-second molding cycle, the piston then retracts to open the die and automatically eject the part. The cylinder operates at line pressure (120 to 150 psi.). Temperatures average about 350° F.

PISTON SPEED CONTROLLED IN BOTH DIRECTIONS

Operation is controlled by a 4-way Modernair CRV-410 lever-operated valve. Speed control was desired in order to close the die with a squeeze instead of a slam, and to eject the molded part gently.

This was accomplished by installing Modernair Exhaust Speed Control Valves in each exhaust port on the CRV valve (see photo).



Simplest, most economical speed control you can use! All Modernair 4-way valves have separate threaded exhaust ports for both ends of the cylinder. You can get piston speed control in either or both directions simply by installing the inexpensive Modernair Exhaust Speed Control Valves shown here. Speed is easily adjustable, "stays put" where set.

TOGGLES INCREASE PRESSURE ON LARGER PRESSES

The press shown is one of more than 20 air-operated molding presses used in the Ultronix plant. Larger presses use toggle action to multiply the force of the air piston to attain the necessary closing force on the dies. Many presses are equipped with air-operated index tables for higher production speeds.

NEW CATALOG READY

Most comprehensive ever published in the fluid power industry, this 72-page manual is an invaluable handbook for those who want to put fluid power to work. A note on your company letterhead will bring your free copy promptly. Write today, please address Dept. E-7.

MEMBER NATIONAL FLUID POWER ASSOCIATION

Why wait for the "Factory of Tomorrow?" *— You can get the cost-saving, production-boosting benefits of automation* now *with versatile, low-cost Modernair cylinders, valves and fluid power components.*

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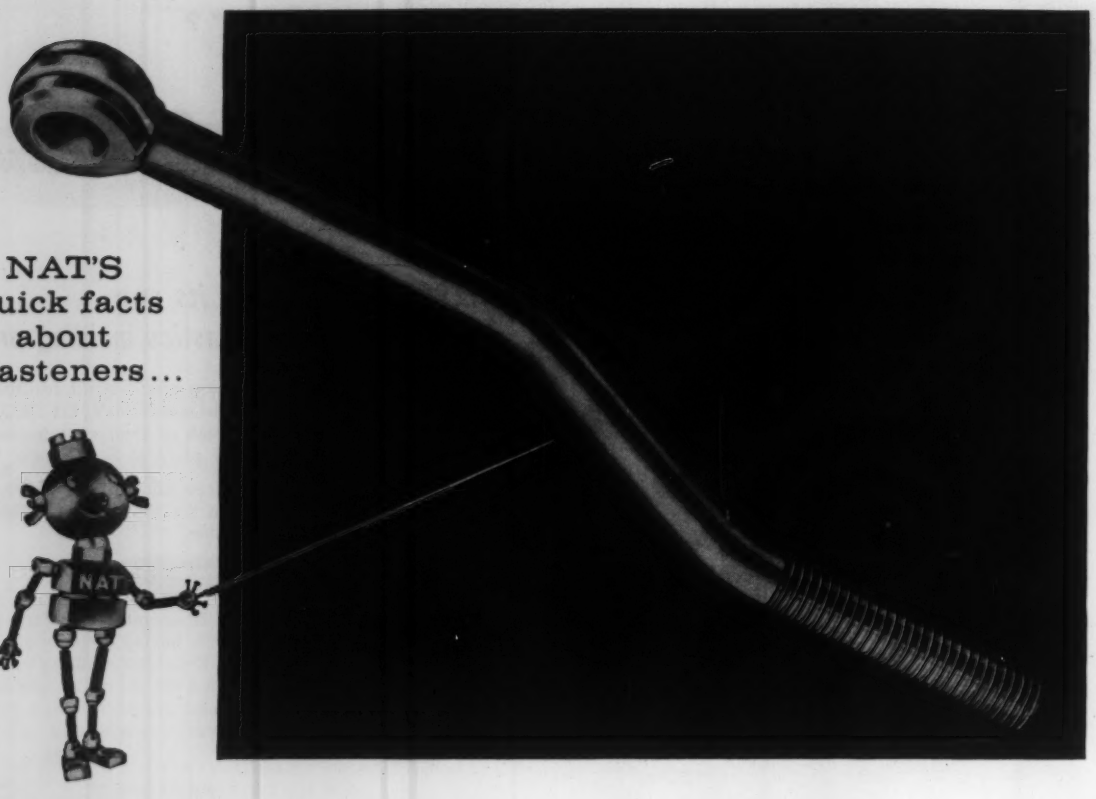

Shining example...of big things in **specials** by National

This is a large offset eyebolt, shown here big as life. We designed and made it to order for one of our customers.

To begin with, it shows that we can and do make some sizable things in the way of cold headed Special Products.

But there's more here than seems to meet the eye.

When our customer brought us this eyebolt, he had been having it made as a forged eye welded to a machined bolt, with a cut thread.

We gave it some thought, then made it... with a difference. We cold formed it in one piece, and rolled the thread... turning out a stronger, more practical, and more efficient part, and lopping off costs all along the line.

And there's the real point... what we really mean when we mention doing BIG things in Specials, at National... better parts, large or small, at lower cost, by cold heading and designing for profit.

We do it right along, and we can very likely do it for you, too. Want to find out? Just drop a note to Special Products Service, at our address*. And if you just happen to have a Special problem, tell us all about it—and let us help.

*It will bring you this illustrated booklet "Bring your Special Problems to National", 16 pages about Specials as National sees them.

National Products

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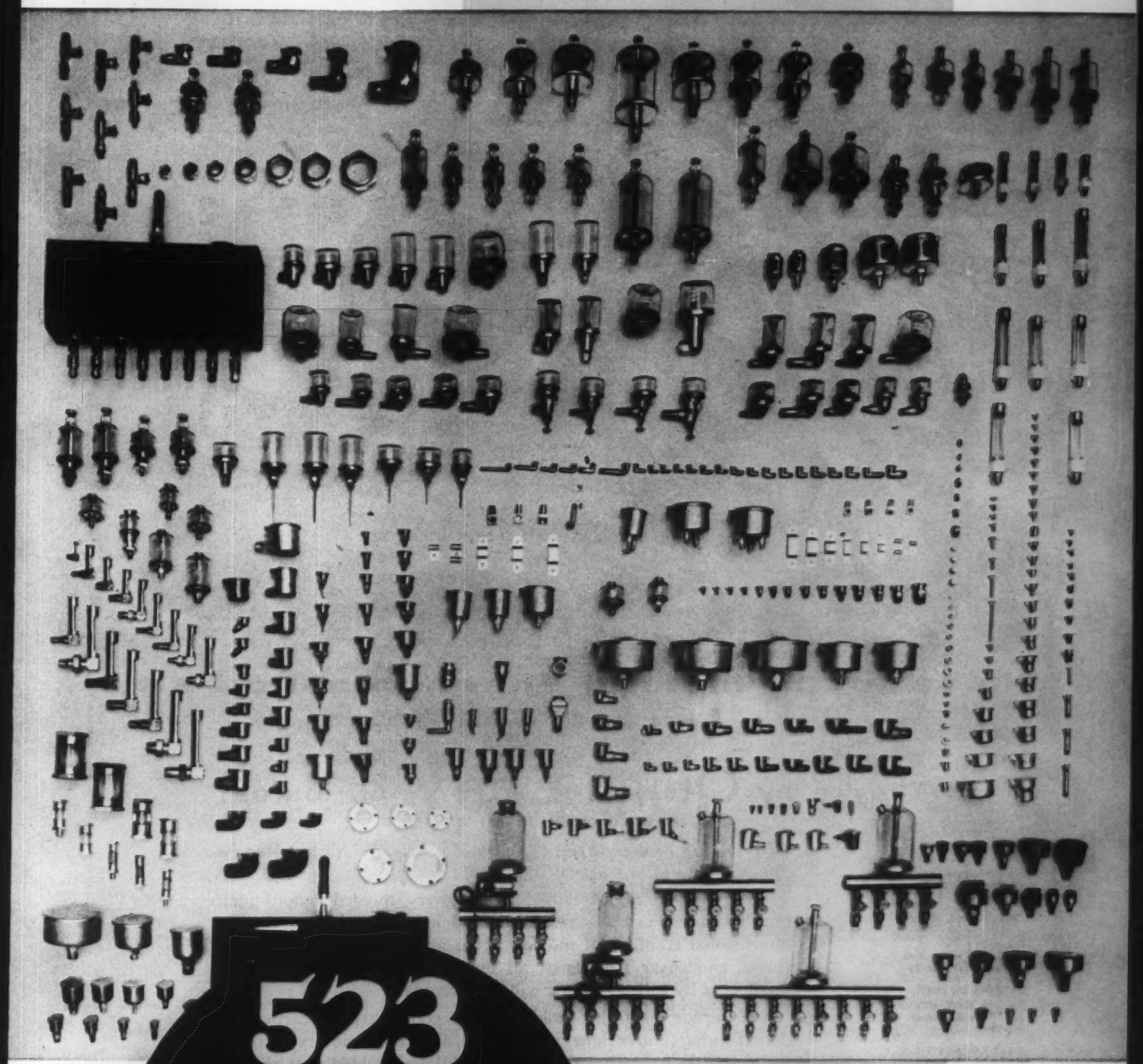
California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

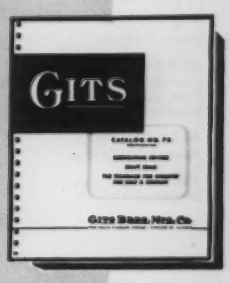
Circle 467 on Page 19



523 GITS OILERS AND GAUGES READY TO SHIP

Largest selection available anywhere. You save time and money, because the one you want is always right in stock. Send for complete Catalog.

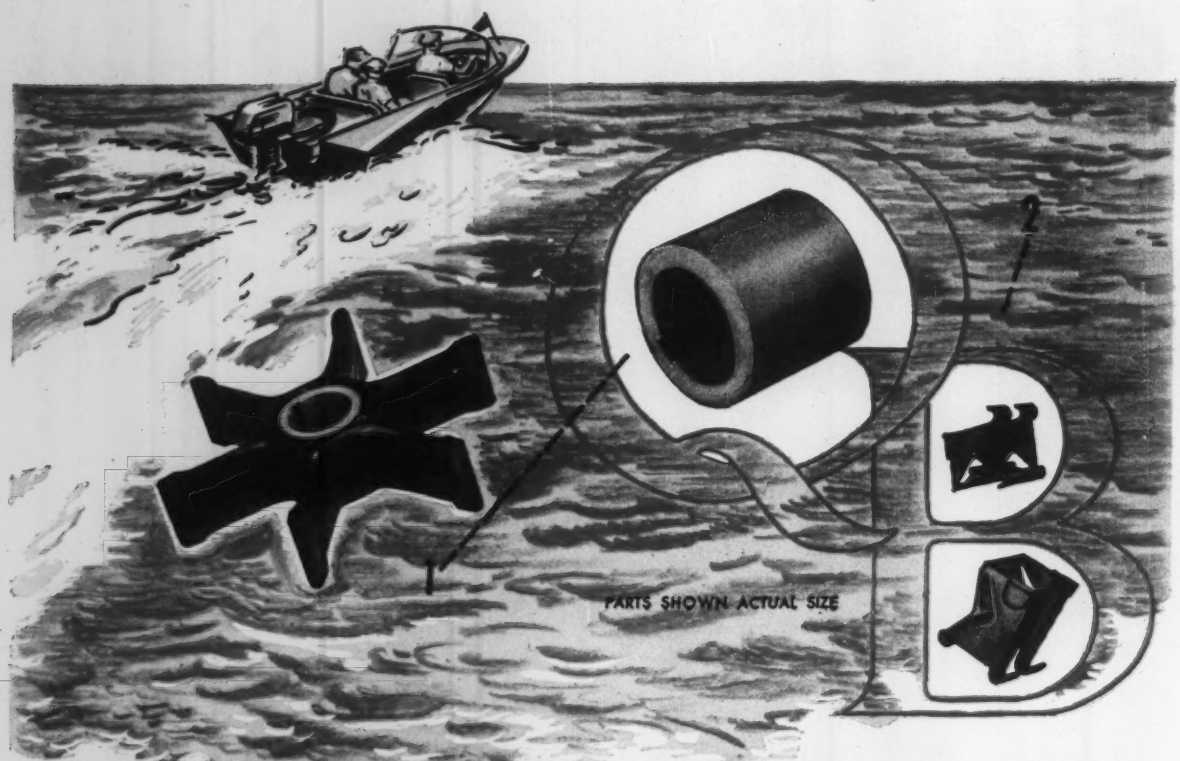
Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century



GITS BROS. MFG. CO.

1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 468 on Page 19



These tough molded Thermoplastic Parts Laugh at Salt Water

They're by Quinn-Berry, of course!

"WHERE THE UNUSUAL IS ROUTINE"

Here are two good examples of Quinn-Berry contributions to the improvement of end products.

1 At the left above is the Quinn-Berry molded nylon pump impeller insert used in Evinrude's 50 hp. Starflite motor. The dimensional stability of molded nylon affords tough resistance to thrust and shear stresses at all temperatures . . . and nylon is unaffected by salt water. It will not corrode.

2 Evinrude uses the molded nylon combination bearing and detent spring (above right) in the 10 hp. and 18 hp. motors to control the position of the choke. This Quinn-Berry molded part requires a minimum of lubrication, has excellent wearing characteristics and salt water will not corrode it.

Consult with us on your component parts design and material requirements. Quinn-Berry molded thermoplastics are doing a good job in a wide diversity of applications.

CHELSEA 50, Mass.
Joseph Leeder
68 Marlborough Street
Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
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16577 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

KNOXVILLE, Tennessee
Harold J. Malloy
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QUINN-BERRY CORP.

2609 WEST 12TH STREET, ERIE, PA.

CUSTOM MOLDERS OF ALL TYPES OF THERMOPLASTICS

Modern carburetors need the protection of new

PUROLATOR FUEL FILTERS

Particles of dirt only 10 microns in size are large enough to cause flooding or stalling in modern carburetors. Effective *positive* filtration is essential for delivering the clean fuel modern four-barreled carburetors must have for efficient operation.

Purolator's new Micronic® fuel filters are designed specifically for the requirements of modern carburation. They are compact, light-weight units with a positive type Micronic element sealed in a Terneplate steel housing.

The little unit shown measures only 2⅜" x 1⅝"—but packs 52 square inches of filtering area into a housing capacity of 4.5 cubic inches. The low-cost, easily replaceable unit gives completely effective filtration — and long life.

The Model GF-11 is already in use as original equipment on many engines. It is easily incorporated into any fuel line. For full specifications on the GF-11 and other Purolator fuel filters, write to Purolator.

Filtration
For Every Known
Fluid

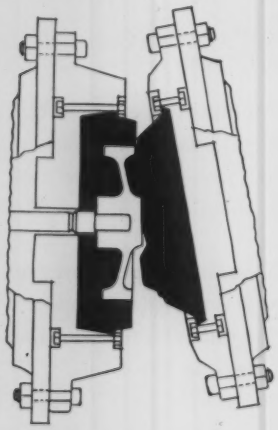
PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle 470 on Page 19

Unique Mill Forges and Rolls circular products in one operation

In less than one minute, this Bethlehem mill—the only one of its kind in the country —turns out a top-quality impression-die steel forging at a cost that's hard to match.

This is Bethlehem's famed circular-products mill—the Slick Mill. Named for its designer, Edwin E. Slick, this unique machine produces impression-die circular forgings ranging from 10 in. to 46 in. OD; as-rolled weights ranging from 100 to 2,000 lb. It handles almost any grade of steel—carbon, alloy or stainless, as well as certain heat-resistant grades.

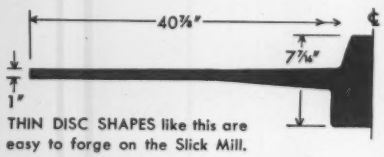


How It Works

Designed to operate in a horizontal plane, Bethlehem's Slick Mill is constructed with two *revolvable* spindles on which face plates are mounted. These face plates support the impression dies that form the steel billet into shape by a combination press and rolling action.

After the steel billet is heated and descaled, it is centered between the dies of the Slick Mill. Then a 1500-ton hydraulic ram actuates the spindle on the straight side of the mill, upset forging the billet. When this cycle is completed, a 2,000-hp motor actuates the spindle on the angle side of the mill and the rolling cycle begins. By continuing the upsetting action and rotation of the dies and work, the material flows into the recesses of the dies, resulting in the desired shape. *The entire rolling cycle takes about one minute.*

After rolling, excess material in the form of flash is sheared off; the hub, when necessary, is punched; and the forging is inspected.



THIN DISC SHAPES like this are easy to forge on the Slick Mill.

Cost-Saving Features

Quick operation: Only one minute is needed to convert a heated slug into a contoured forging, whether the product weighs 100 or 2,000 lb.

Quick die changes: Only 15 minutes are needed to change and set up dies. Even production runs as small as 25 or 50 pieces are economical.

Low die charges: Since contact time between die and work is very brief, and because there is no impacting, low-cost die blocks can be used. In many cases, die charges are ⅓ to ½ less than conventional impression dies.

Less steel needed: Utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength.

Good physical characteristics: The process insures excellent grain flow, machinability and soundness.

Bethlehem's Slick Mill is readily adapted to jobbing or production quantities of forged circular products such as: gear blanks, fly wheels; crane track wheels; sheave wheels; brake drums; clutch discs; couplings; tire moulds; and turbine or compressor wheels. Products may be specified as-rolled or rough machined to specifications.

Your inquiry—whatever the quantity involved—will receive prompt attention. Call or write the Bethlehem sales office nearest you today.

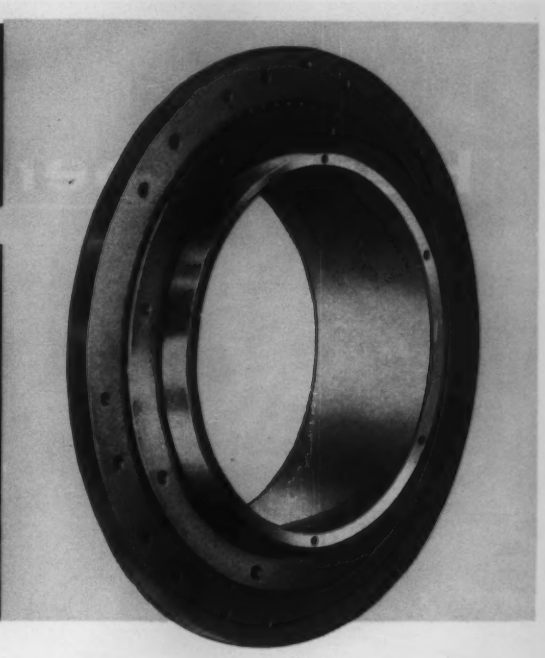
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 471 on Page 19



The HEART of this
Brunswick-Balke-Collender AUTOMATIC PINSETTER

is an Aetna Ball Turret Bearing

. . . chosen for accuracy, dependability and unfailing service on an exceptionally intricate piece of equipment—a marvel of design and production ingenuity.

The entire mechanism revolves on this one bearing. After collecting and elevating the pins, they are positioned in a revolving "turret" where they are held until the last pin is received. As this last pin drops through the center of the Aetna bearing, it activates the catch mechanism and pins are released into position in the "deck." The "deck" in turn sets the pins upright with correct spacing and arrangement on the alley bed ready for bowling.

Quick, dependable performance is the key to the success and widespread adoption of the Brunswick Pinsetter. It must function perfectly, steadily, accurately—game after game, day and night—without maladjustment, breakdown or delay—and it is in just such service that Aetna Bearings prove their stamina, perfect workmanship, accuracy and dependability. Despite the fact that the pins vary slightly in weight, the Pinsetter continues to perform smoothly and accurately on its main Aetna Bearing which remains in correct alignment at all times and operates quickly, smoothly, unfailingly load after load.

Equal performance and dependability are built into your products when you specify Aetna Ball and Roller Bearings. Call your local Aetna representative listed in the Yellow Pages of your Classified Telephone Directory, or write direct for General Catalog and Engineering Manual.

AETNA BALL AND ROLLER BEARING COMPANY

Aetna

DIVISION OF PARKERSBURG-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

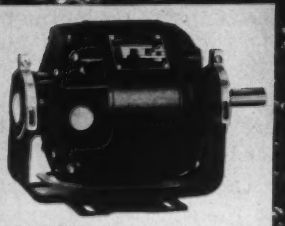
ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

Here Experience Counts

Sure, sometimes luck helps out a fisherman . . . but in the long run it is experience that pays off. And it is experience that pays off when it comes to solving power-drive problems for appliance and equipment manufacturers . . . the kind of experience Emerson-Electric offers *you*.

Remember . . .

- Emerson-Electric produces *custom-engineered* motors to suit *your specific needs*.
- Emerson-Electric has more than 100 engineers for on-the-spot service for *you*.
- Emerson-Electric has more than 65 years' experience in solving motor-drive problems *like yours*.

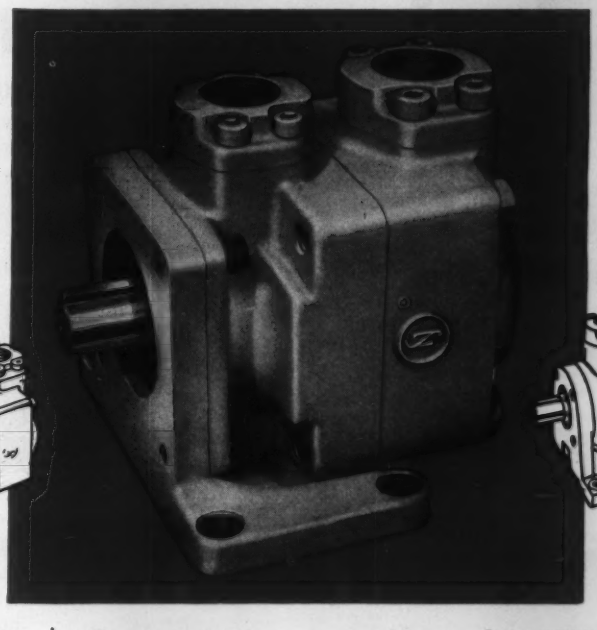


To get the kind of experience that counts, call, wire or write Dept. M383 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

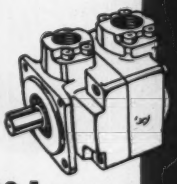
EMERSON-ELECTRIC *of St. Louis · Since 1890*

HYDRECO® Announces—

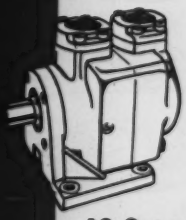
TWO NEW SERIES OF DUAL-VANE PUMPS FOR 2000 PSI CONTINUOUS OR INTERMITTENT OPERATION



PF-200



14.5 to 38.1 gpm
at 1200 rpm-0 psi



PF-300

43.0 to 72.5 gpm
at 1200 rpm-0 psi

CHECK THESE FEATURES

The greater efficiency and economy of 2000 psi *single stage* operation.

●

Dual-Vane construction—the proven principle of hydraulic balance—higher mechanical and volumetric efficiency.

●

Improved design of cam ring provides greatly increased cam life.

●

Two sizes give complete range of capacities from 14.5 to 72.5 gpm . . . PF-300—300 Double Pumps give capacities to 144 gpm.

●

Cartridge construction . . . Pump rotation can be changed by merely reversing cartridge.

●

Housing ports can be rotated to any position 90° to each other.

Member NFPA

NFPA NATIONAL FLUID POWER ASSOCIATION

Design engineers, seeking Vane Pumps that deliver substantial improvement in performance, longer service life and higher over-all efficiency will find much of interest in these HYDRECO Dual-Vane Pumps. Whether the application imposes the exacting performance of automated production machinery or hydraulic presses, these HYDRECO Dual-Vane Pumps possess the long-sought extras.

For continuous or intermittent 2000 psi operation, these Pumps are outstanding. Within the capacity range of 14.5 to 144 gpm obvious applications include: Injection Molding, Die Casting, Hydraulic Presses, Scrap Balers and Metal Working Machinery. There are many other areas wherein the advanced design and high performance features of HYDRECO Dual-Vane Type Pumps will excite special interest. Write for full information today.

Write

for Bulletin 10420.1 and performance data

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
9006-7 EAST MICHIGAN • KALAMAZOO • MICH.

Please send me Bulletin 10420.1 and performance curves on Series PF-200 and PF-300 HYDRECO Dual Vane Hydraulic Pumps.

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Company_____

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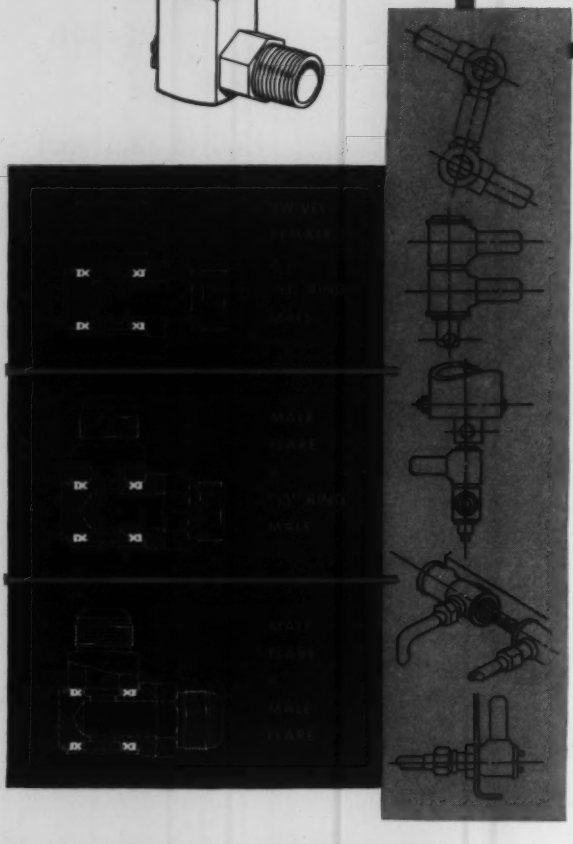
Circle 474 on Page 19

Eastman offers INDUSTRIAL SWIVEL CONNECTOR

to eliminate hydraulic hose failure under severe flexing

Licensed Under Pat. No. 2481404



If you have been designing "around" metal swivel joints because of high cost, EASTMAN now offers an economical swivel connector for industrial use—precision engineered to assure adequate freedom of motion—proved under the most rigid government requirements.

Unique design assures "balanced" flow of hydraulic fluid at required pressure—at any angle. Fluid pressure is also balanced by a ***double seal*** assembly at each end of stem. Pressure-Balance assures equal internal pressure, causing the body to float about the stem, free of end load and friction.

Eastman Swivel connectors will make your flexing installations the most reliable link in your Hydraulic Assembly.

APPLICATIONS:
For use on Cranes, Loaders, Earth Moving Equipment, Hydraulic Presses, Shears, etc.—wherever unusual flexing and exposure may shorten hose life or cause premature failure and frequent replacement.

ECONOMY:
Permits use of shorter hose lengths since less hose allowance is needed for complete extension. Shorter lengths of longer lasting, multiple spiral wire high pressure hose may be used, since Swivel Connector absorbs flexing motion.

ADAPTABILITY:
Body of Connector available with any combination of ends. Now available in types and sizes shown at left. Various combinations of stems can be interchanged with any body style.

WRITE, WIRE or CALL about Eastman Swivel Connector Opportunities in Your Line.

STANDARD SIZES AND COMBINATIONS AVAILABLE

•

LOW TORQUE—Freedom from friction, even under high pressure.

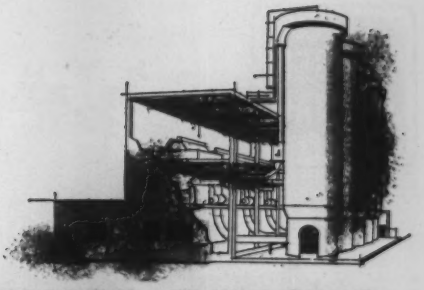
WIDE RANGE—Operating pressures up to 5000 PSI. Trouble-free operation through wide temperature range.

ROTATION—Full 360° for all manifolds.

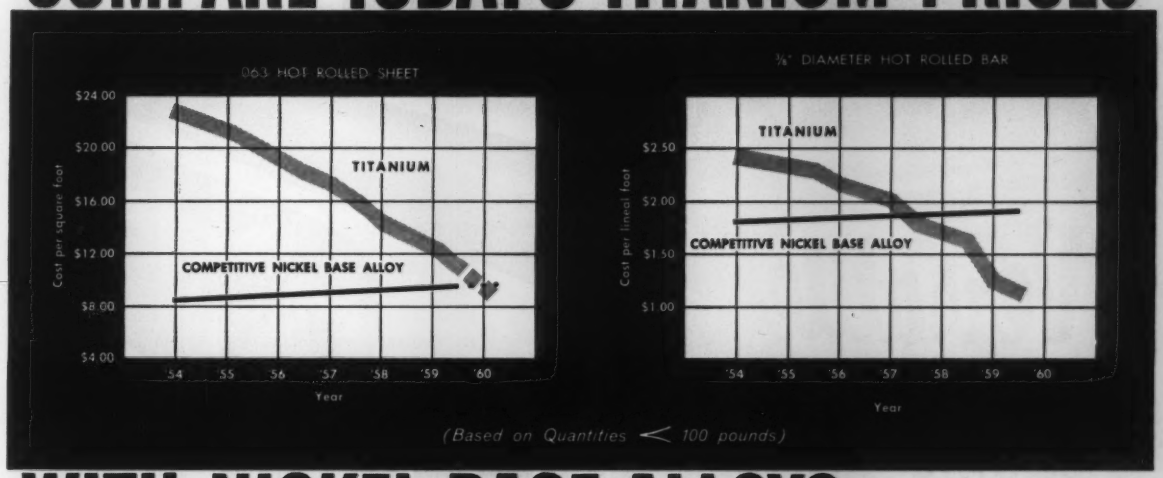
SIZES—Steel, plated for corrosion protection—½" thru 1½".

Eastman
first in the field MANUFACTURING COMPANY
Dept. MD-7, MANITOWOC, WISCONSIN

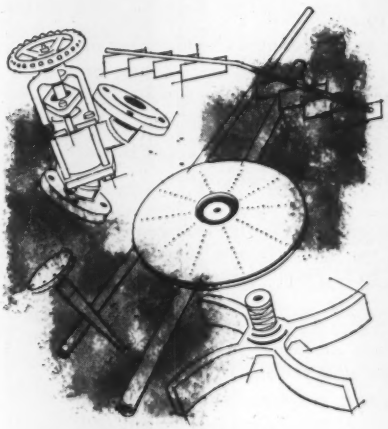
SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER



COMPARE TODAY'S TITANIUM PRICES



WITH NICKEL BASE ALLOYS



Write for *Technical Data Sheets on "Cost Cutting Ideas in Titanium" for:*
- *The Pulp and Paper Industry*
- *Chemical Valves, Pumps and Accessories*
- *Metal Treating Applications*

Address: Commercial Market Development, Department C, Mallory-Sharon Metals Corporation, Niles, Ohio.

For industrial applications, Titanium offers important savings

Titanium prices have come tumbling down . . . to the point where you can actually save money by specifying and using Titanium where you are now using nickel base alloys.

A 52% price reduction has already been realized in the last five years. And the best part of it is that Titanium prices can be expected to go still lower while other metals will probably increase in price.

This will be possible because of improved melting practice and rolling techniques, plus increased production as more and more users become familiar with Titanium's corrosion-proof characteristics, increased service life, and reduced downtime advantages.

Mallory-Sharon will gladly work with you in designing Titanium into your products or applications and will be pleased to show your production men how easy it is to form, machine, weld or fabricate Mallory-Sharon Titanium.

Write us, now, so that you can start at once to *save* with Titanium.

MALLORY MS SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium · Zirconium · Special Metals

BARBER COLMAN

Founded in 1900 for the purpose of building textile machinery, Barber-Colman Company today produces diversified equipment and products for such fields as automotive, aviation, machine tool construction and textile.

Versatile ACIPCO

centrifugally spun TUBES ...for super speed warpers

Barber-Colman Company, Rockford, Illinois, manufactures more than 85% of the section beam warpers produced in the world. And Barber-Colman specifies ACIPCO Centrifugally Spun Cast Iron Tubes as supplied through our mid-west distributor, C. A. ROBERTS CO.

The Super Speed Warpers produced by Barber-Colman have a winding speed of 900 yards per minute yet these units are also engineered for low and uniform tension to produce a beam in which thread ends are stressed alike.

Specifications for the machines are strict: tubular metal parts must be machined to a fine finish and to precise measurements. They must have high strength and be balanced so that they are capable of withstanding sustained high speeds. ACIPCO tubes **custom-fit** requirements such as these.

Centrifugally Spun ACIPCO tubes have a dense, non-directional grain structure which is easier to machine. Important, too, their **inherent** dimensional stability and concentricity makes dynamic balance easier to attain in finished products.

If your machines or products employ tubes of stainless steel, carbon steels, alloy irons, or special analyses as components, it will pay you to investigate ACIPCO. Call or write for complete information on ACIPCO tube applications in your field. No obligation, of course.

SIZE RANGE: Lengths up to 410″ have been produced to meet modern machinery requirements. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION
AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

ACIPCO

Both now available off-the-shelf!

Morse double-pitch chain and sprockets... the perfect pair for double wear!

When it comes to single-strand chain for low-speed applications, you just can't beat Morse double-pitch chain coupled with Morse double-pitch, double-duty stock sprockets. These Morse components provide a lighter, smoother, more compact transmission—with much longer life than regular pintle, conveyor, or fabricated chain. And both are available for immediate off-the-shelf delivery.

You see, Morse double-pitch chain is precision-made to A.S.A. standards, lightweight, and smooth running—just like Morse roller chain! Packed conveniently in 10-ft. lengths, Morse double-pitch chain is available in 1″ to 2″ pitch in power transmission and 1″ to 2½″ pitch in conveyor series.

And Morse Taper-lock® double-pitch stock sprockets—with "alternate-tooth" design of 17, 19, 21, 23, 25, or 35 teeth—give you double the wear over ordinary sprockets; available off-the-shelf, *require no additional machining!* Unique easy-on, easy-off Taper-lock assembly minimizes costly downtime, too!

So, whether you're concerned with packaging or farm machinery, conveyor or timing drives (or with most any transmission problem—up to 500 rpm), Morse double-pitch transmission chain and double-pitch stock sprockets are the answer! Check with your Morse distributor today. He's listed in the Yellow Pages under "Power Transmission." Morse Chain Company, Industrial Sales Dept. 6-79, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

MORSE MORSE B-W *Trademark

A BORG-WARNER INDUSTRY

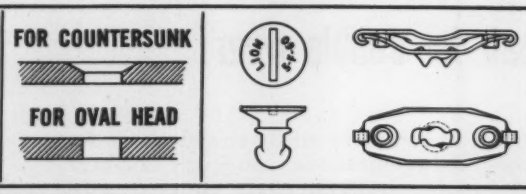
ONLY MORSE OFFERS ALL FOUR: Roller Chain, Silent Chain, Hy-Vo® Drives and "Timing"® Belts.

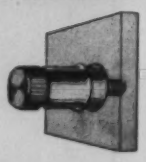
Captive Quick-Opening Fasteners:

Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

LION ¼ TURN FASTENERS

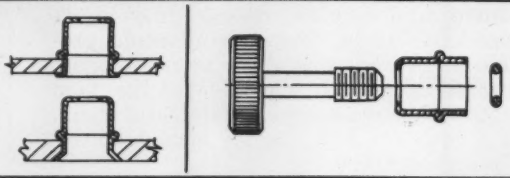
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.

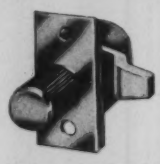




RETRACTABLE SCREW FASTENERS

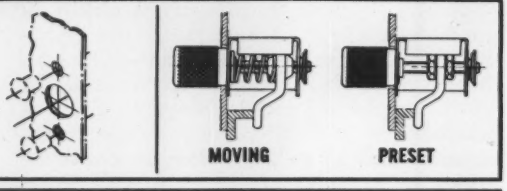
Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.

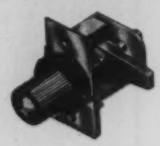




ADJUSTABLE PAWL FASTENERS

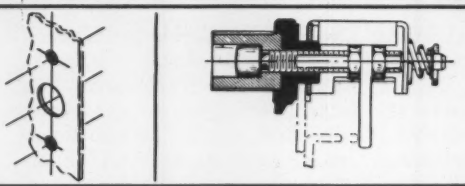
Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.





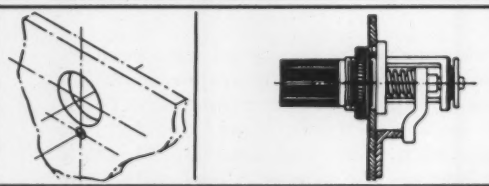
ADJUSTABLE PAWL FASTENER

Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.



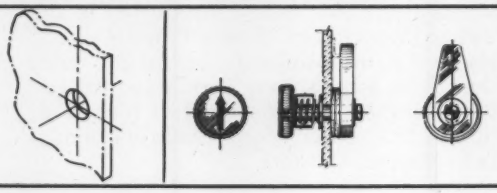
ADJUSTABLE PAWL FASTENER

Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.



ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



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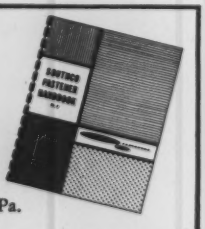

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Circle 479 on Page 19

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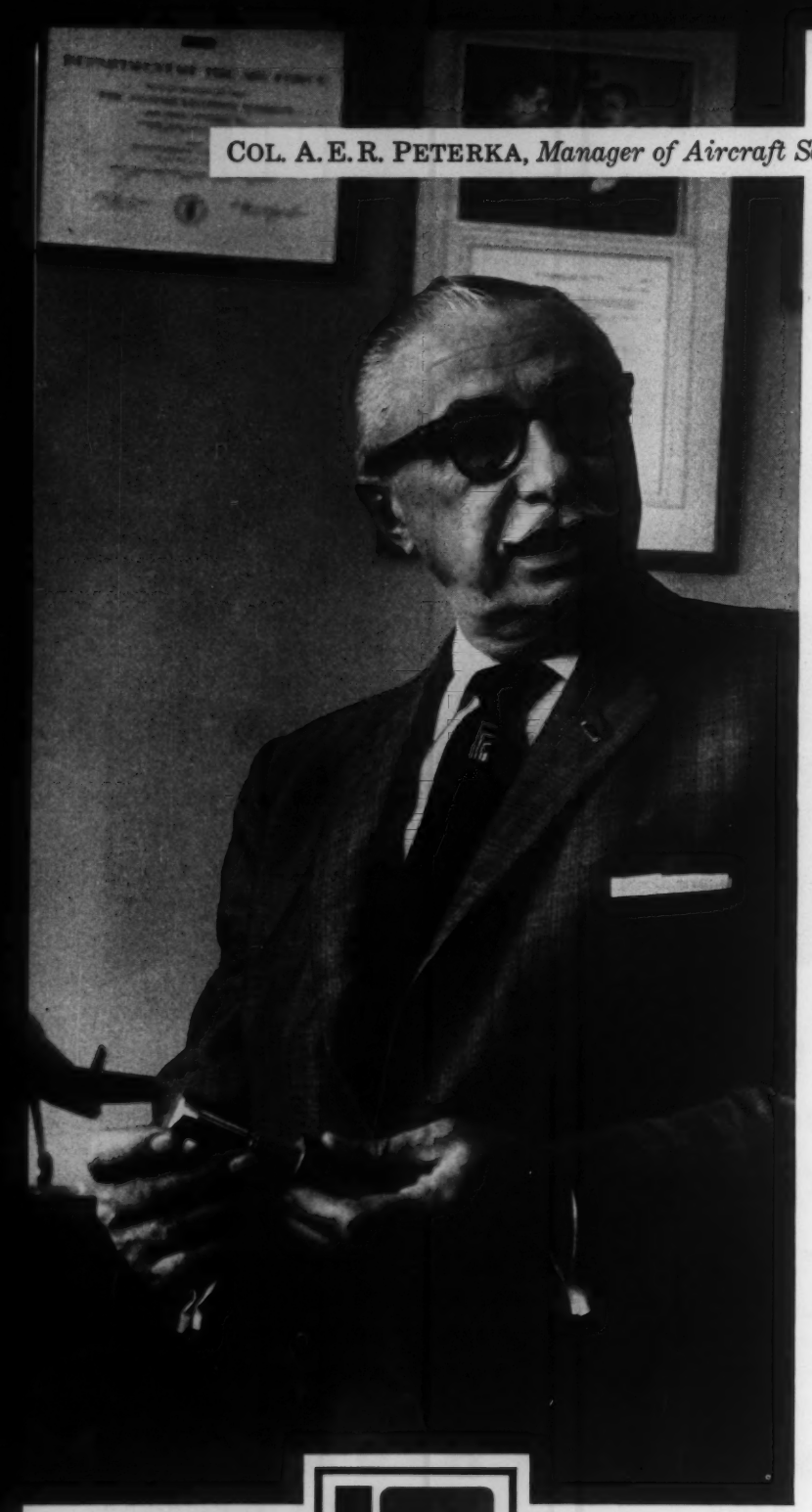

COL. A. E. R. PETERKA, *Manager of Aircraft Sales, Lamson & Sessions, tells why...*

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Circle 481 on Page 19

ROCKET DESIGN
July 23, 1959

Not for Amateurs

PRODUCT finding, these days, is like patriotism and motherhood. Everyone is for it. But management is sometimes less than generous in backing up its faith with dollars.

The reason isn't hard to see. Finding new product ideas can be like looking for the proverbial needle in a haystack. There's no guarantee when you will find what you are seeking—especially if you don't know what it looks like.

Harry Toulmin likens research to exploration. He quotes Admiral Byrd as saying, in effect, "A professional gets all the facts, studies all the obstacles, and plans accordingly. He does not need to be rescued."

Product finding is exploration too. But, as Zuce Kogan points out in this issue, ". . . few of the disciplines and organization concepts that mark the maturity of other management fields have, thus far, been extended to product-finding activities." That is why, even in "large corporations with extensive research facilities . . . only one new product out of five survives."

The systematic approach which Mr. Kogan outlines is like Admiral Byrd's geographical surveys and logistic studies. It should appeal strongly to skeptical management people disillusioned with the results of "waiting" or even "scouting" techniques. And it should result in more survivals and fewer rescues.

Only amateurs need to be rescued.

Colin Carmichael
EDITOR

Sound engineering alone does not guarantee success of a new product. The idea itself must have a fighting chance. So—the first step is . . .

finding the right new product

A systematic procedure is recommended here. It is compared with two others that only seem to be easier and less expensive.

ZUCE KOGAN
Consulting Engineer
Chicago, Ill.

PRODUCT-MINDED companies today are faced with a disturbing fact: Mortality rate of new products is high. Available data on large corporations with extensive research facilities show only one new product out of five survives. Smaller companies don't fare as well.

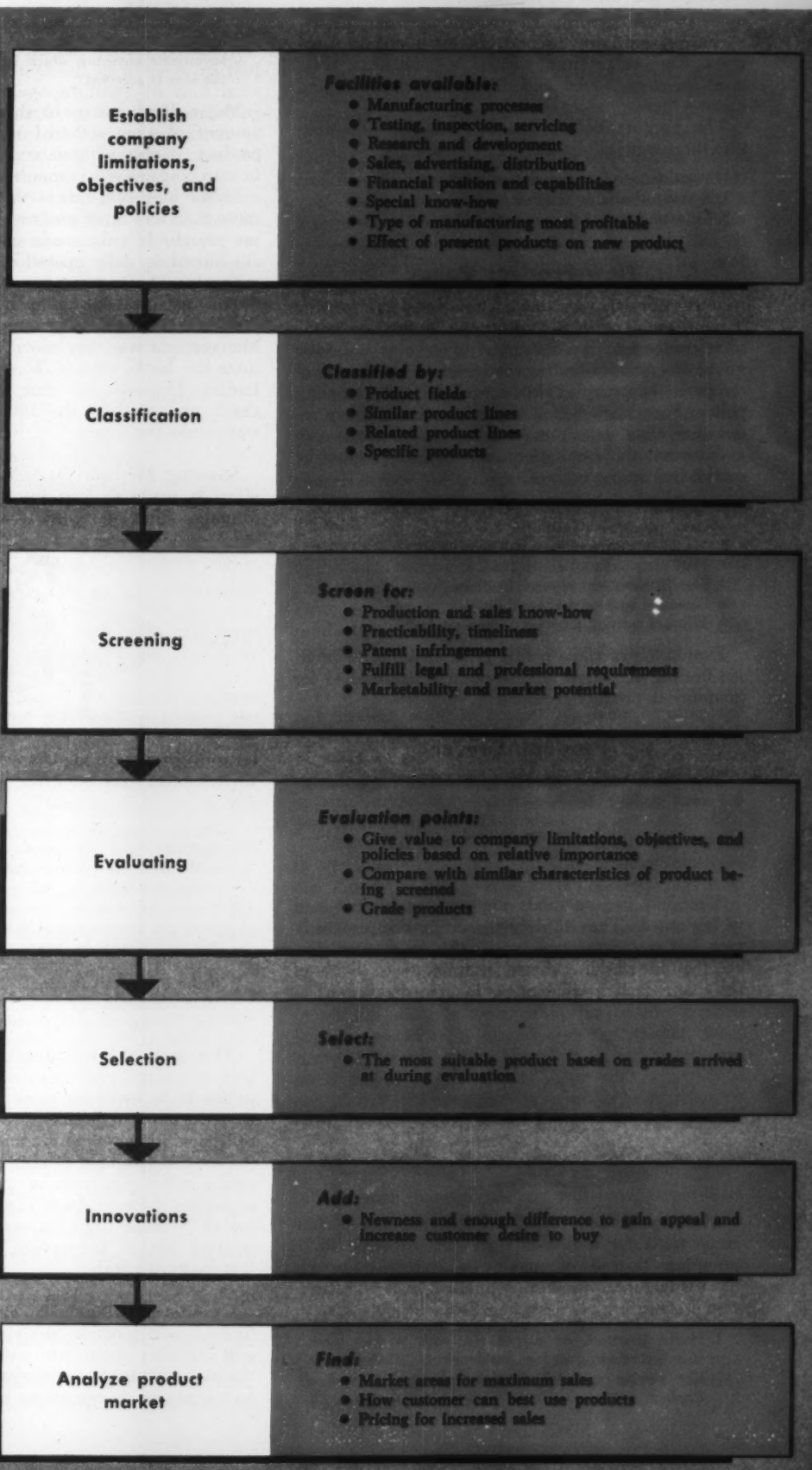
Why do so many products fail? The main reason usually can be traced to lack of effective method in finding low-risk products with high profit potential. However, few of the disciplines and organization concepts that mark the maturity of other management fields have, thus far, been extended to product-finding activities.

To date, the task of finding and selecting suitable products has generally been considered as part of the overall function of product development. But this view can be a misleading—and dangerous—oversimplification. Evolution of a product has two distinct stages: 1. Finding the product idea. 2. Developing the idea into a marketable product. These functions, like mathematics and arithmetic, are closely related but differ widely in principles and concepts. Only the first stage—product finding—will be considered here.

Basic Concepts

For maximum effectiveness, the product-finding operation begins with a study of company product policies. It covers the factors and procedures involved in searching for, screening, and evaluating new products. It includes determination of the marketability of a potential product. It ends when the product is isolated and ready for development by engineering. Elements of the product-finding function are depicted graphically in the accompanying chart.

Finding and selecting successful product ideas re-


Establish company limitations, objectives, and policies
Facilities available:
• Manufacturing processes
• Testing, inspection, servicing
• Research and development
• Sales, advertising, distribution
• Financial position and capabilities
• Special know-how
• Type of manufacturing most profitable
• Effect of present products on new product
Classification
Classified by:
• Product fields
• Similar product lines
• Related product lines
• Specific products
Screening
Screen for:
• Production and sales know-how
• Practicability, timeliness
• Patent infringement
• Fulfill legal and professional requirements
• Marketability and market potential
Evaluating
Evaluation points:
• Give value to company limitations, objectives, and policies based on relative importance
• Compare with similar characteristics of product being screened
• Grade products
Selection
Select:
• The most suitable product based on grades arrived at during evaluation
Innovations
Add:
• Newness and enough difference to gain appeal and increase customer desire to buy
Analyze product market
Find:
• Market areas for maximum sales
• How customer can best use products
• Pricing for increased sales

quire pioneering initiative that differs from the engineering creativity essential to development functions. Knowledge from various management areas must be co-ordinated and directed toward bringing about a "new-product sense."

The product-finding function can be organized into three general phases:

1. Formulation of a new-product policy.
2. Search for suitable products.
3. Determination of the product market.

New-Product Policy

Satisfactory new products cannot be found on the basis of ambiguous generalizations. A detailed frame of reference must be developed to serve as a specific guide in product-finding activities. This frame of reference is provided by a well-defined company policy. Formulation of a realistic product policy requires a clear definition of what the company can and cannot do. Limitations and objectives must be established on the basis of:

1. Company product background and emotional make-up of policy-making staff.
2. Manufacturing facilities and know-how.
3. Marketing facilities and policies.
4. Development and research facilities.
5. Financial position and capabilities.
6. Effect of existing products on new products.

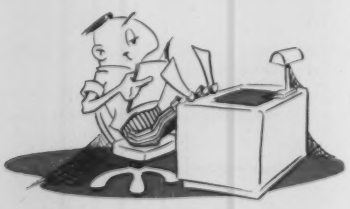
Evaluation of these points gives direction to product-finding activities. A base point is established for guidance in product decisions.

Product Search

The three most common approaches for uncovering new-product ideas are:

1. Waiting method
2. Scouting method
3. Classification method

The first two methods are well-established and widely used. The third approach is comparatively new but was developed specifically to sharpen perspective in tracking down product ideas. Each of these approaches will be examined in detail.



Waiting Method: With the first method, a company waits for a new-product idea to come to its attention instead of making a concerted search.

This method of obtaining product ideas is a three-step process:

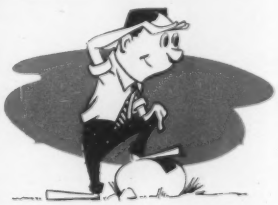
1. Invite inventors, or anyone else with product ideas, to submit their ideas for consideration. Effect is much like placing a classified advertisement: "Wanted—a Product. . ."
2. Assign an individual, or a committee, to analyze and evaluate the product ideas.
3. Investigate anything which incurs no obligation until the idea is accepted.

Major disadvantage of this method is the great amount of time required to hit upon a suitable product. It goes without saying that the time spent in searching is a gift to competition.

In the long run, this method is expensive. It costs more than any other program set up to make a product search. It only seems cheap because the costs are buried in daily operations and are never really exposed.

For instance, one company was able to find a product after considering some 2000 submitted ideas. Management was very proud of the accomplishment since the books showed no expenditure for product finding. However, the time spent to select, discuss, check and analyze the 1999 other product ideas was overlooked.

Scouting Method: In this approach, a definite effort is made to look into various sources of information that may lead to a product idea, regard-



less of how remote the chances of getting ideas from these sources may be. These idea sources are:

1. Recorded sources. These include papers and industrial magazines announcing new products, licenses available from government and industry, and advertisements by inventors and idea men looking for a manufacturer to buy or handle their ideas.
2. Unrecorded sources. Company salesmen and plant personnel are encouraged to look out for product ideas. Ads are placed in newspapers and periodicals announcing interest in product ideas.
3. Indirect sources. Personnel are sent to visit bankers, industrial development commissions, trade associations, etc., for suggestions on product ideas.

This method of finding new product ideas is, in many cases, well-organized and planned. Its objective is to leave no stone unturned. The hope is that the laws of probability will eventually force a collision with a desired product.

The disadvantage of this method lies in the excessive effort put forth with only a meager chance of hitting on a product. The tendency, as the number of fruitless trials increases, is to accept a new product out of frustration, regardless of whether it is the most suitable.

Classification Method: The third approach for finding new products analyzes all possible products and classifies them into categories that best meet the predetermined requirements. These products may be variations or extensions of existing products, or

they may be completely new ideas generated by analysis of existing or potential market possibilities. This method can be compared, in a sense, to that used in the field of fingerprinting. To find from among millions of fingerprints the one particular fingerprint that matches another, a collection of fingerprints is analyzed, sorted, and then classified in a manner that permits simple matching.

The analogy is valid here because somewhere among the millions of products now on the market, there is an idea for one that best matches the established requirements. Finding that product calls for an easily administered method of comparing product characteristics.

FUNDAMENTAL CONCEPTS: The classification method is based on the following premises:

1. Effective investigation leading to the unknown starts with the known. To find the new product, products now on the market and being sold must be investigated to see which one could fit the requirements best.

2. The greater the number of known products analyzed, the greater the likelihood of finding the one sought.

3. Overall criterion for suitability of a new product is its ability to meet the requirements of the company as organized and expressed in terms of a company policy.

4. Each product has its own characteristics just as fingerprints have their own patterns. All products have manufacturing, sales, advertising, development, and financial requirements, which are distinctive. For instance, one product requires more precision, more educational-type advertising, more promotional-type advertising, and larger inventory than another product. Thus, this product may have characteristics totally out of line with company policy. These product requirements or characteristics become an essential basis for classification.

5. Once a product is classified by its characteristics, it can be screened and evaluated. It is screened to see how many, and to what degree, product characteristics meet the policies of the company. For instance, where service facilities are neither available nor desirable from a policy standpoint, a product requiring service must be graded less desirable than one devoid of service requirements.

6. The wider the scope and the more accurate the definition of product policies, the better the product characteristics can be distinguished and the more exacting and detailed can be the classification. Sharper delineation makes for reduced risk in selecting the desired product.

7. To reduce an otherwise time-consuming task, the multitude of products must be grouped into product fields, product lines, and specific products. In this way, product fields can be analyzed and classified to determine which one best meets the company requirements or policies. Once specific product fields have been determined, all other fields can be ignored. This reduces the scope of the search and focuses attention on the most promising area.

8. The product field selected can be broken down into product lines and specific products. Product lines are subjected to analysis and classification first to determine which ones are most suitable. The most promising ones are selected and set aside for expansion. Then, the selected product lines are broken down into specific products which are subjected to similar analysis. Through such repetitive distillation, the specific products desired are most efficiently handled and analyzed for suitability.

OPERATING FEATURES: The classification method provides a scientific basis for finding new products. It permits close evaluation of a product. As product characteristics are brought out in detail, the preference for one product over another is easily distinguished.

In addition, this method eliminates the tendency of various personnel of the Product Committee to pull in different directions on product decisions. Once a product policy has been established, the product which best meets this policy automatically becomes the product which is most suitable.

Product Analysis: To obtain a product that will not be just another competitive item requires the introduction of originality. It is necessary to think of what is not yet available on the market, what new features can bring a product into a new field or application, or what innovation will add to the usefulness or appeal of a product.

Here the requirement is not so much engineering or technical know-how as it is creative ability—the knack of being able to temporarily lay aside accepted facts and dig for the new and unknown. Training in creative thinking techniques and methods can be helpful in this specialization.

When a product is selected, a detailed description or report, including preliminary drawings, should emphasize what is new, what makes the product superior to what is already on the market, what makes it appealing, etc. This work should be followed by a patent search to make sure that whatever is considered new has not previously been patented either in part or as a whole.

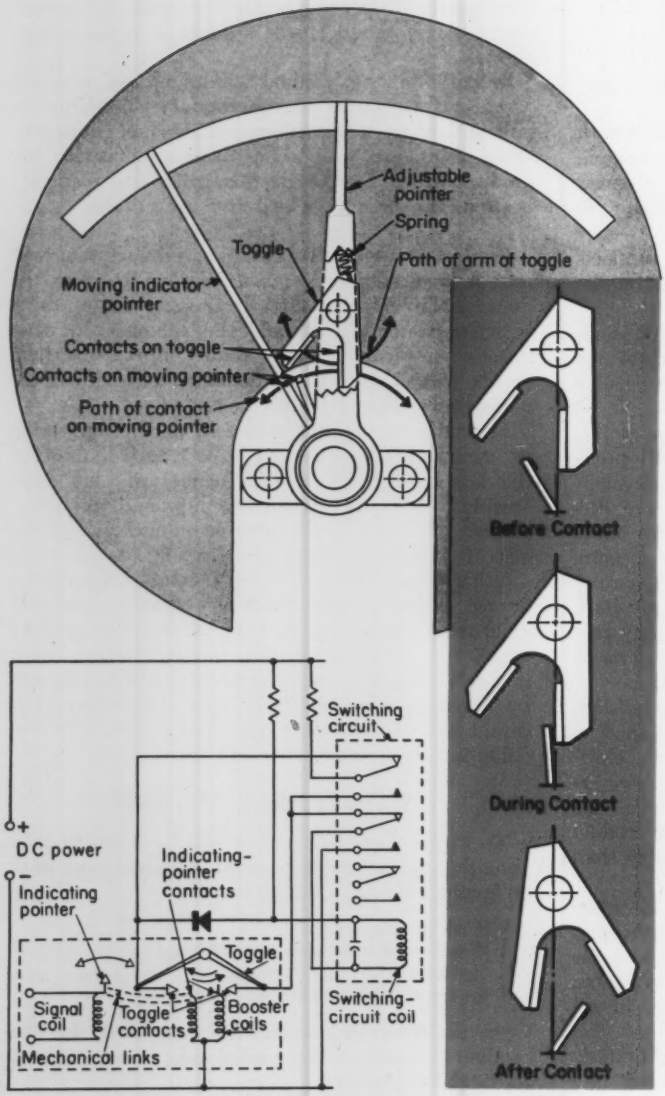
New-Product Market

To assure that the product will have ample sales potential, all factors that would influence sales must be investigated. Such factors include:

1. Potential sales areas.
2. Ways in which the product will be used.
3. Optimum price range or ranges.
4. Sources of direct and indirect competition.

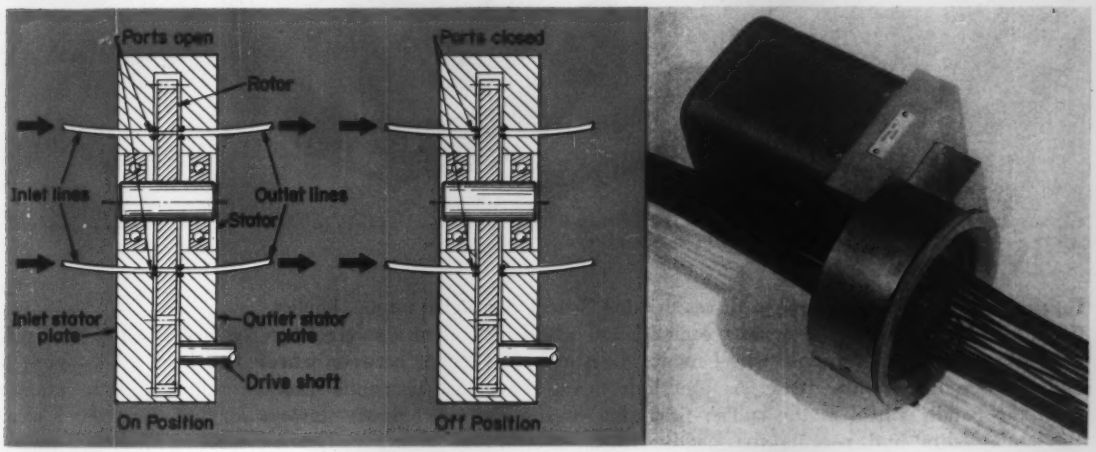
Once the marketing studies are completed, the new product is ready to be turned over to engineering for final development.

scanning the field for *ideas*

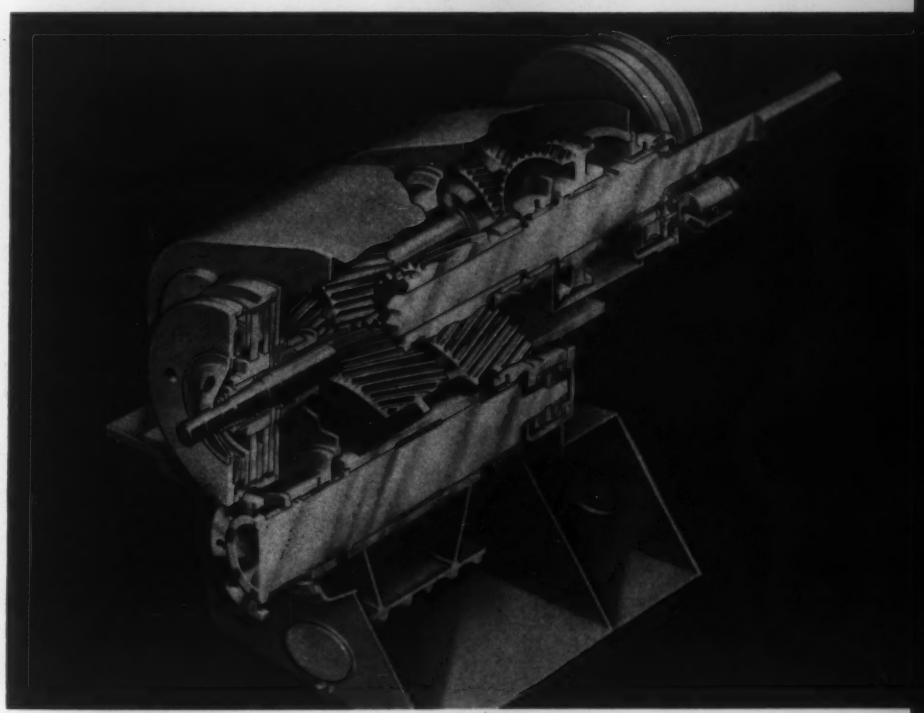


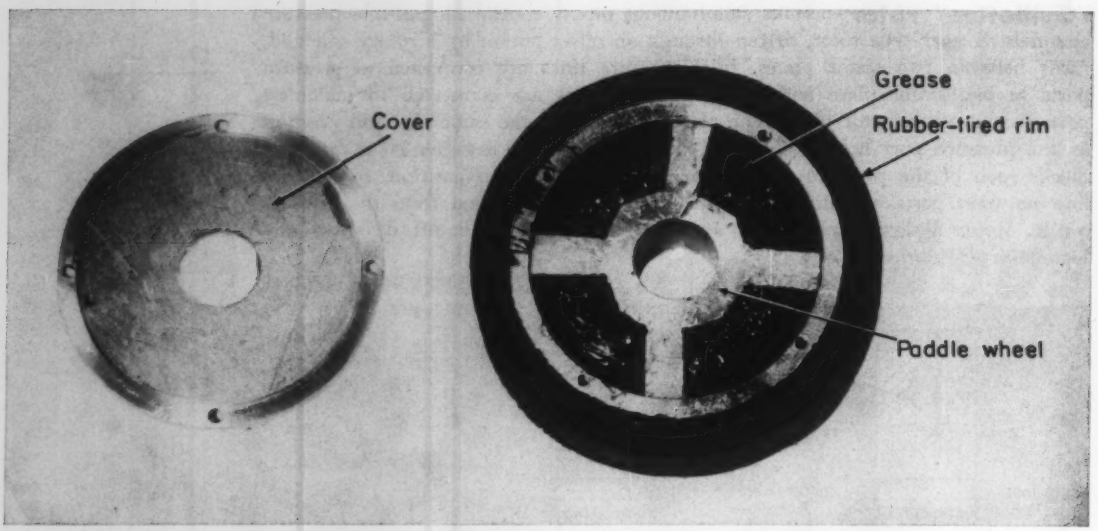
Toggle-action contacts give positive two-way switching action to permit full-scale readability in instrument control circuits. A V-shaped toggle, with separate circuit contacts on its arms, is pivoted on the underside of an adjustable pointer that marks a set point. The toggle is designed and positioned to permit a contact on an indicating pointer to pass by the near toggle arm and to strike the contact on the far arm. The indicating pointer, which is operated by a low-current signal coil, has two isolated contacts. One pointer contact touches a toggle contact while moving up scale; the other pointer contact operates when the pointer moves downscale. When moving upscale, the indicating pointer contact meets the toggle contact, energizing the booster coil to maintain contact and the switching circuit coil to initiate control action. The switching-circuit coil sends a surge of current through the booster coil. This action supplements the torque of the indicating pointer which kicks the toggle and moves past it, deactivating the booster. The switching circuit remains operative and the indicating pointer moves freely with fluctuating field strength above the set point. When the indicating pointer returns to the set point, the booster is activated and the switching circuit is deactivated. The pointer then kicks the toggle and moves past it downscale, again deactivating the booster. Principle employed in a meter relay developed by Assembly Products Inc., Chesterland, Ohio.

"Guillotine" rotor permits simultaneous on-off control of multiple pressure channels. A gear type rotor, driven through an offset pinion by a rotary solenoid, turns between two stator plates. Inlet pressure lines are connected to pressure ports in one stator plate and outlet pressure lines are connected to matching ports in the other stator plate. The rotor has holes of the same size and position as the pressure port holes. In the off position, the area between holes on rotor blocks each of the pressure ports. When rotated to the on position, rotor holes line up with ports, permitting the pressure to be transmitted from the inlet to outlet. Rotor design employed in an instrument pressure cutoff developed by Datex Corp., Monrovia, Calif.

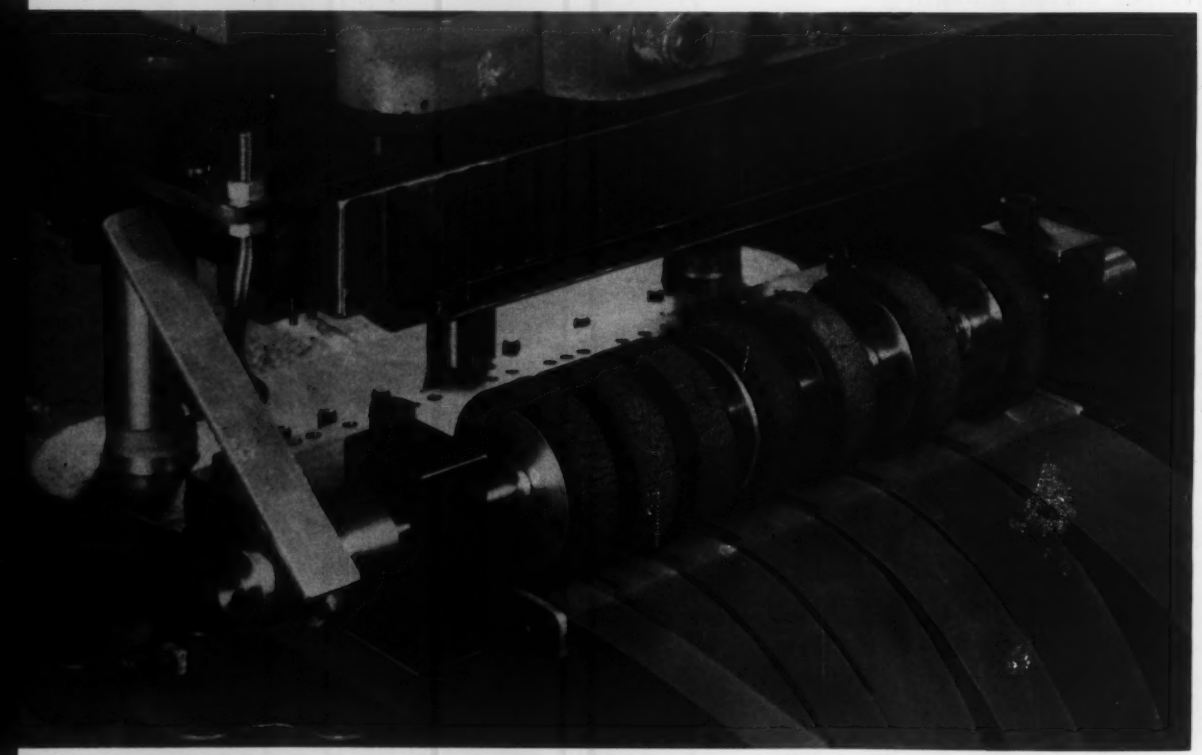


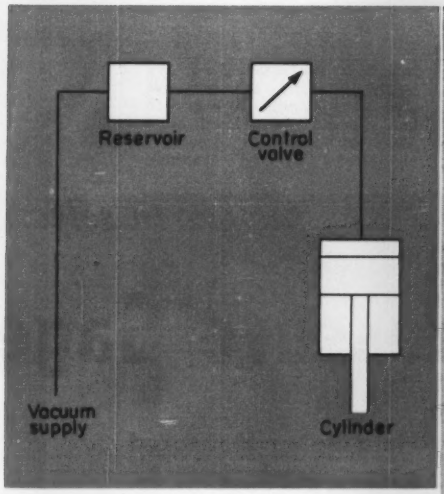
External clutch mounting minimizes air flow restrictions to provide maximum cooling under controlled slip or reversing operation. As a departure from conventional practice of mounting clutches between engine and gear unit, two pneumatic clutches are mounted on the forward and aft ends of a gear-unit shaft. This location permits free air flow to cool clutches without additional equipment. In addition, inspection and maintenance of clutches is simplified by unobstructed location. Mounting design developed for marine speed reducer by Western Gear Corp., Belmont, Calif.

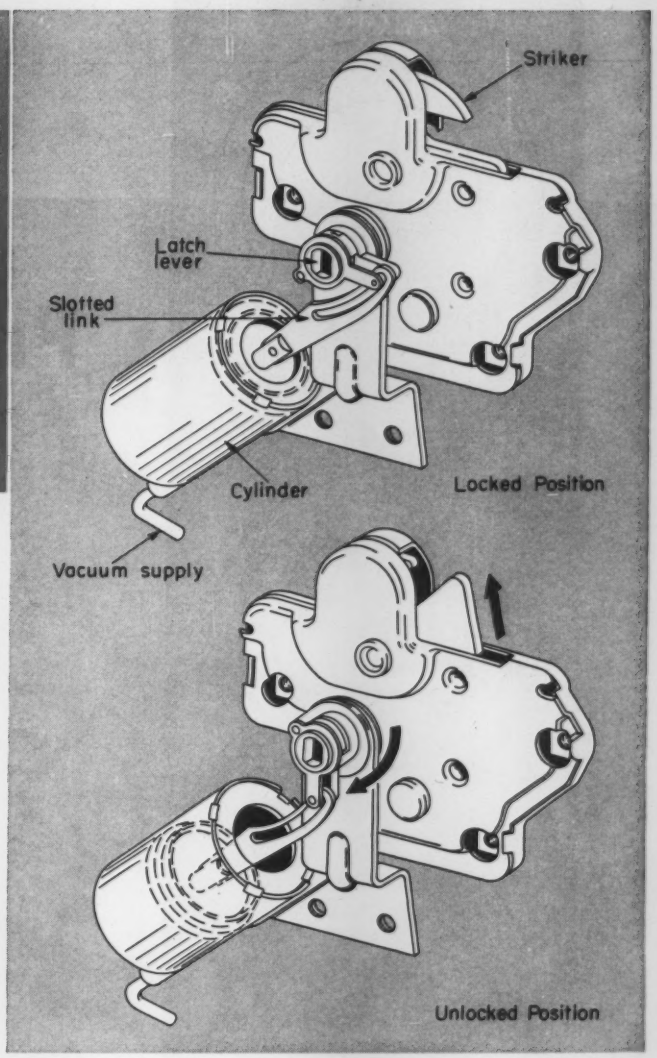




Grease-filled slip clutch drives friction wheel for light torque applications. Used in series as feed devices, each friction wheel consists of a soft, rubber-tired rim and an inner paddle wheel mounted on a shaft. Cavities between wheel and rim are filled with grease. As the shaft turns, the grease transmits torque from the paddle wheel to the rubber-tired rim. As the rim slows down or stops the clutch slips and permits the paddle wheel to continue rotation. Driving torques are varied with greases of different viscosities. Reported by R. W. Fullerton, design was developed by Packard-Bell Electronics Corp., Los Angeles, Calif.

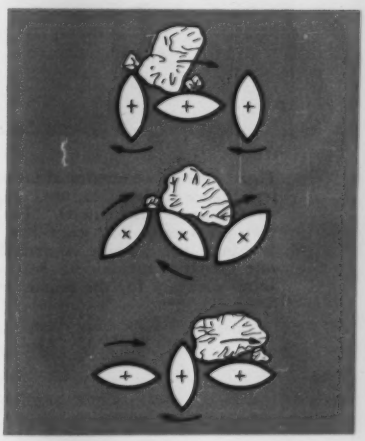






Remote latch operation is provided by vacuum cylinder actuation of slotted-link mechanism. In a latch assembly, the striker is spring loaded in a locked position. As vacuum is applied to the cylinder, the cylinder piston retracts. This action causes the latch lever to turn, rotating the striker into locked position through cam action and releasing the striker pin. When vacuum is broken, the striker returns to locking position. Latch design developed for power-operated trunk release by Oldsmobile Div., General Motors Corp., Lansing, Mich.

Phased elliptical rollers convey bulk materials without belts or sliding members. Rollers are mounted with every other unit rotated 90 deg out of phase with adjacent rollers. As the high side of each roller rotates to the top, the material is "worked" down the conveyor. Since each roller rotates in the same direction and about its own fixed center, only one driving source is needed. Roller design employed in crushing unit developed by Hammermills Inc., subsidiary of Pettibone Mulliken Corp., Cedar Rapids, Iowa.



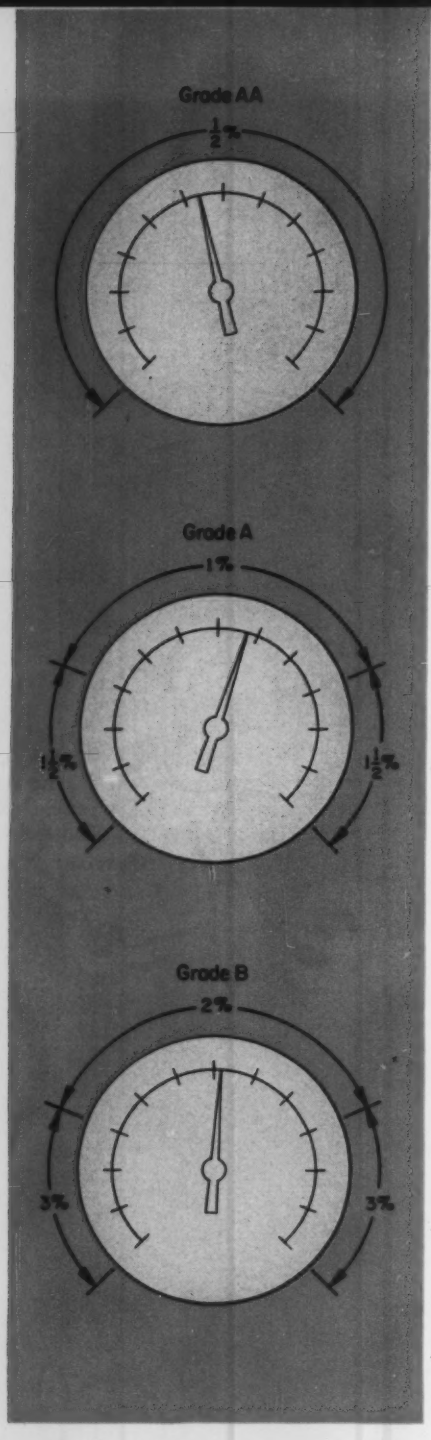


Fig. 1—Gage accuracies according to American Standard classifications. Percentages are of full-scale graduations. For example, a 600 psi Grade AA gage has an accuracy within 3 psi. Grade A and B gages have one accuracy for middle half of scale, another accuracy for the remainder of scale.

Key factors in selecting

Pressure Gages

Fluid Being Measured
Pressure Range
Atmospheric Corrosion
Wear Conditions
Connections
Mounting
Readability
Accuracy

W. L. BUFFENMYER
Chief Application Engineer
United States Gauge
Div. of American Machine and Metals Inc.
Sellersville, Pa.

WHEN systems or equipment are powered or controlled by fluids or gases, performance often depends upon the pressures or pressure changes which exist. To ensure proper operation, the correct gage must be selected to indicate the pressure. In addition, proper gage selection can circumvent many malfunctions.

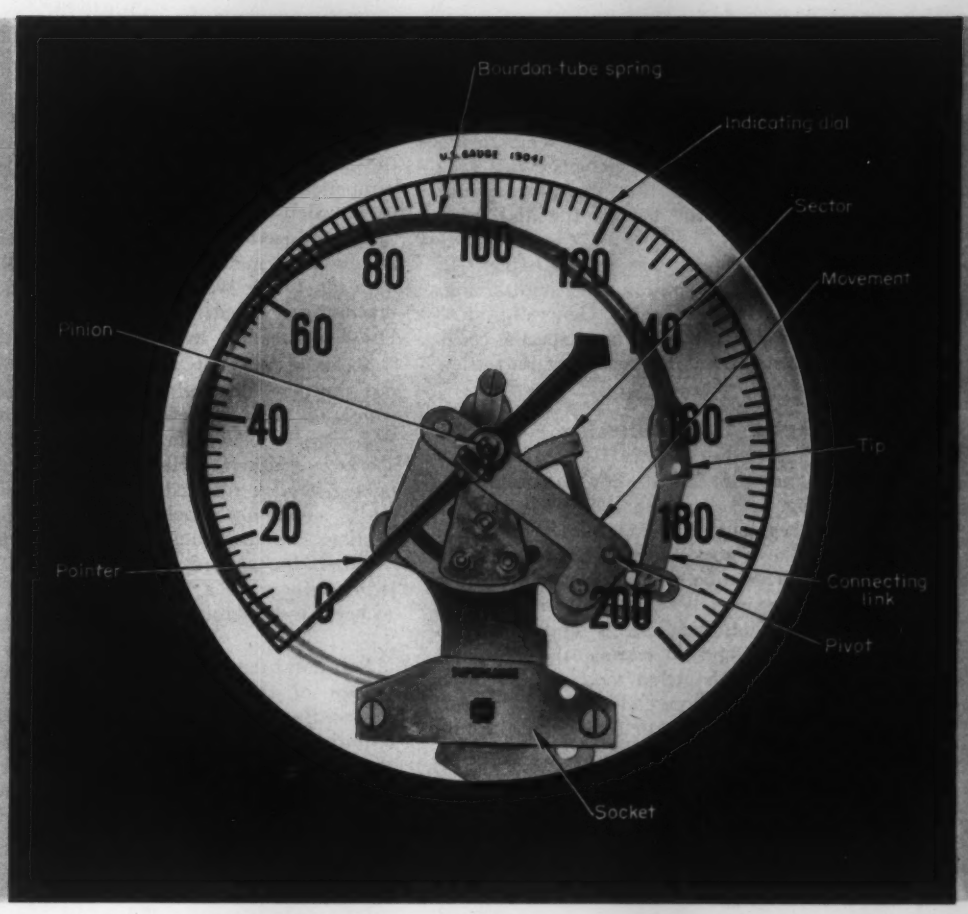
This article deals primarily with indicating dial gages of the Bourdon-tube type used for pressure measurements in the range of 30-in. Hg vacuum to 10,000 psi. The objective is to provide the designer with information and characteristics that are helpful as well as necessary for proper gage selection.

General Classifications

Pressure gages are commonly classified according to accuracy (by ASA Standards), case style, and end use. Specific properties of each gage type are given in *Gage Classification Methods.*

The *American Standard Indicating Pressure and*

Fig. 2—Construction of typical Bourdon-tube pressure gage. Selection of right gage depends upon the accuracy, strength, and corrosion resistance of components.



Vacuum Gauges, B40.1-1939 (reaffirmed 1953), contains common gage terminology and is widely used for gage classification. This standard covers basic gage definitions and specifications and establishes accuracy limitations for the various gage classifications, Fig. 1.

Classification of gages by ASA standard accuracies automatically affects other gage specifications. For example, Grade AA gages of ½ per cent accuracy are not generally offered in dial sizes smaller than 4½-in. diameter, since the readability of smaller sizes is not sufficient to permit readings to this accuracy. In addition, manufacture of gages to a high degree of accuracy is more difficult as the gage size decreases.

Case style is another method used for classifying gages. Drawn-case gages are constructed with a metal housing which is deep drawn from sheet steel, brass, or aluminum. Cast-case gages are made from cast iron, aluminum, brass, or phenolic resins. Selection factors such as accuracy, economy, ruggedness, corrosion resistance, and decorative value affect the choice of case materials.

Broad terms, such as commercial, industrial, process, and test, are commonly used to classify gages according to end use. Furthermore, specific names,

such as ammonia, refrigeration, welding, are used because each has special constructions which meet a specific requirement.

There are numerous examples of specific end uses for gages which have given rise to class names which connote certain design features.

One example is the ammonia gage which has stainless-steel internal parts, including the movement and socket. This type is specifically designed to withstand ammonia and its fumes. Scale graduations show both pressure and ammonia temperature equivalents. The ASA standards recognize this specific gage type and indicate that the gage should be plainly inscribed, on the face of the dial, with the word "ammonia."

Other gage names which are self-descriptive of their service include refrigeration, air conditioning, boiler, welding, and sprinkler gages. Generally, these gages are adapted or modified to meet specific codes or specifications established by particular industries.

Gage Components

The basic components for the Bourdon-tube gage are shown in Fig. 2. The spring element is a metal tube, bent in a segment of a circle. One end of the tube is fastened to a socket which connects to the pressure source. The tube is flat on opposite sides and has an approximately elliptical cross section.

Operationally, when pressure is applied inside the tube, the walls tend to assume their original round cross section. This action tends to straighten out the bend. Hence, the free end of the tube moves a small amount. This movement is accurately translated into the rotary motion of an indicating pointer by a linkage and gear arrangement.

Functionally, the components of the Bourdon-tube gage are similar from one gage to another. However, many different styles for each component are available. Hence, the designer must consider how the end use of the gage will effect the various components. The common types, uses, limitations, and materials for each basic component are tabulated for quick reference in *Characteristics of Gage Components*. In addition, the basic functions and less common variations of each element are discussed in the following paragraphs.

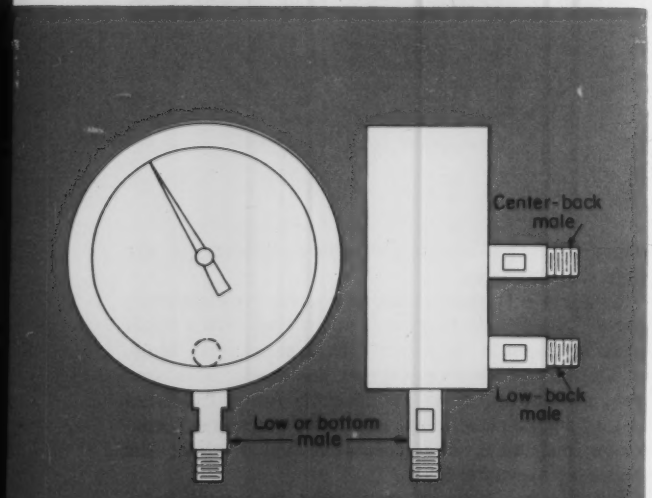


Fig. 3—Socket connections are available in various positions to suit various applications.

Sockets: The socket functions as a means of connecting the gage to the pressure source. Generally, the socket provides support for all the other gage components. Three distinct socket types are used in Bourdon-tube gages: Bar stock, forged, and cast.

For connection to the pressure source, most sockets have a male connection with National Pipe Threads. Other types of connections include female, machine threaded, alligator or hose, flare fitted, Dryseal threaded, and high-pressure threaded.

Socket connections extend from the case in various positions depending on application. The most commonly used types are low male, low-back male, and center-back male connections, Fig. 3. Other special variations include top-connected and right or left-hand connected. Back connections are generally suited for panel mounting, while other connections are for mounting on pipes or equipment.

When the gage is screwed into the threaded female connection, a wrench should be used on the socket to avoid damage to the gage itself.

Bourdon-tube Springs: The most critical component of the gage is the Bourdon-tube spring. Hence, they must meet a number of stringent design requirements. For continued performance, the designer must select the gage with the right tube by considering the nature of fluid being measured, pressure range, over-pressure, shock or vibration conditions, and pulsating pressures.

Tube Linkage: The Bourdon-tube is connected to the gage movement by a tip and link arrangement. The tip seals the free end of the tube and is connected to the tube by soldering or welding, or by a combination of threading and soldering or welding. The type of connection required depends upon the temperature and pressures to which the gage is subjected.

Movements: The motion of the Bourdon-tube's free end is multiplied by the movement, Fig. 2, and changed into circular motion. A small arc movement of the Bourdon tube repeatedly positions the gage pointer over a 270-deg arc movement on the indicating dial.

Two plates with separating columns or posts form the cage of the movement. Within these plates are the shafts which carry the pinion and sector. The sector has a tail which takes the link from the Bourdon-tube tip.

Attached to the pinion, which meshes with the sector gear teeth, is a hairspring with the other end attached to a column. The spring provides tension

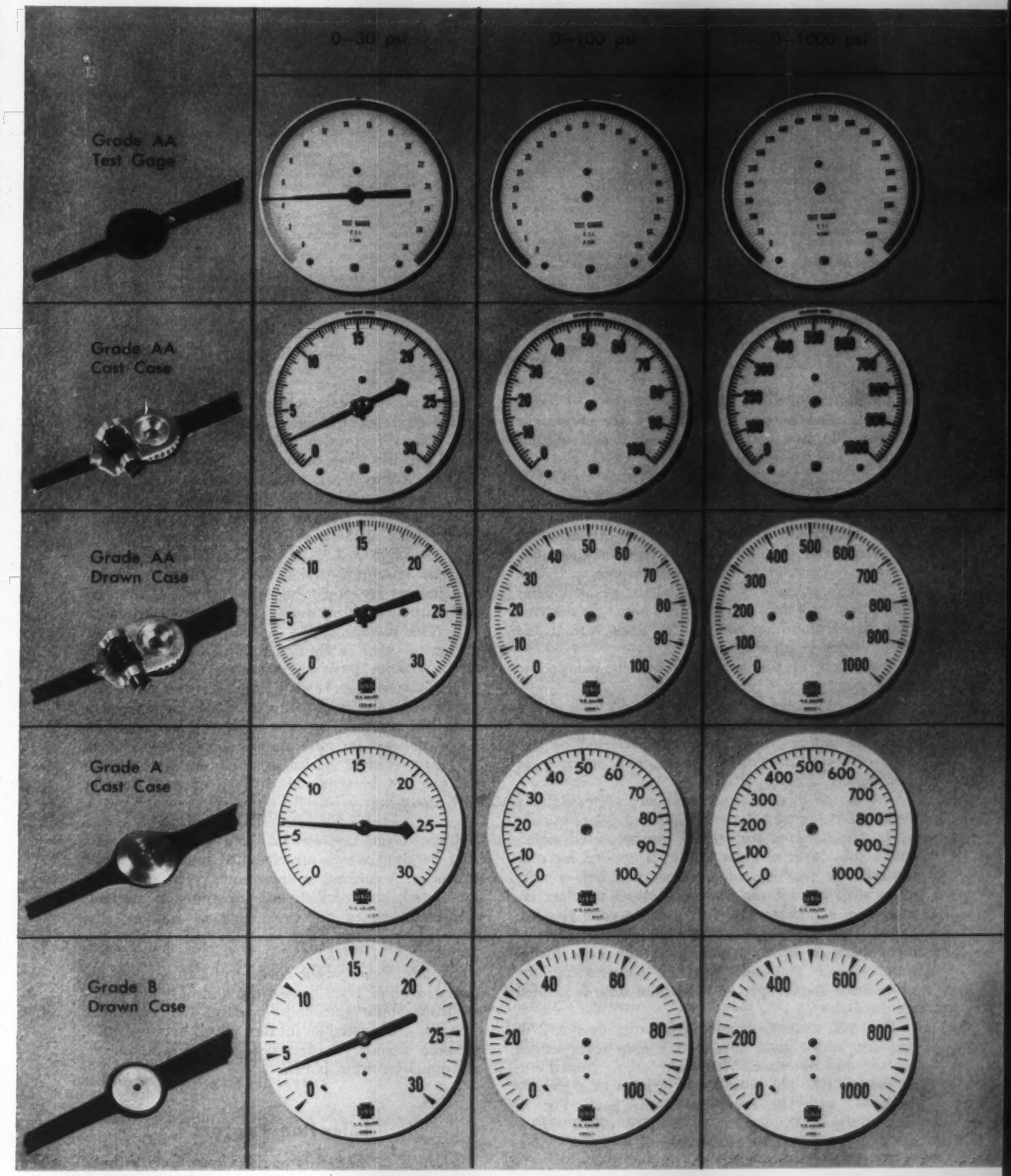


Fig. 4—Dial and pointer styles for various gage classes. Pointer shape and adjustment mechanism is usually compatible with dial accuracy. Dials have various graduations depending upon gage accuracy and the readability desired.

Gage Classification Methods

ASA Standards

Grade AA—Test Gages: Error in pressure indication at any point on scale does not exceed ½ per cent of maximum pressure for which scale is graduated. Widely used in laboratories, production testing, field inspections, test stands, and recalibration work. Also used for process and general industrial applications. Available with better accuracies, such as ¼ per cent, for more exacting measurements.

Grade A—High-Grade Commercial Gages: Error in pressure indication does not exceed 1 per cent of scale range at any point within middle half of scale and 1½ per cent for rest of scale.

Grade B—Commercial Gages: Error in pressure indication does not exceed 2 per cent of scale range at any point within middle half of scale and 3 per cent for rest of scale. Widely used for original equipment applications because of adequate accuracy, ruggedness, and economy.

Case Styles

Drawn Case: Usually ASA Grade B type in dial sizes from 1½ to 4½ in. Can be used economically on original equipment where volume production requires large gage quantities.

Cast Case: Meet ASA Grade A standards or better in dial sizes from 3½ to 16 in., or larger.

End Uses

Commercial: Usually of drawn-case type with ASA Grade B accuracy. Used primarily on items for domestic use; household heating units, fire extinguishers, small pumps, and compressors. Have low unit cost and are devoid of refinements to simplify maintenance and repairs. Often called "throw-away" gages.

Industrial: Usually of cast-case type with ASA Grade A accuracy. Used primarily in industrial application for measuring steam, oil, and water-line pressures. Also used on equipment destined for such applications. Have limited adjustments for repair or maintenance.

Process: Usually of cast-case type with ASA Grade AA accuracy. Used primarily for measuring process pressures in oil, power, and chemical plants. Have long life and reliability, and provide for maximum ease of repair and maintenance.

Test: Includes all gages of ASA Grade AA or better, regardless of application.

on the pinion to reduce backlash.

Metals used at points of contact are chosen to increase life and decrease wear between mating parts.

Pointers: The gage reading is indicated on the graduated dial by the pointer. Weight and shape of the pointer affect the accuracy of the instrument and the precision of the reading. In general, higher accuracy requires more refinements in pointer design.

The pointer mounts on the shaft which carries the pinion of the movement. There are several methods of mounting the pointer, each with a different degree of adjustability.

The shape of the pointer is usually compatible with the accuracy of the dial, Fig. 4.

Dials: The dials, Fig. 4, contain the necessary scale graduations and are usually selected on the basis of cost, corrosion resistance, and accuracy of graduations.

One of the most common dial forms consists of a metal plate coated with a background color, usually white. Graduations are printed on the coated metal, and a thin layer of clear plastic is applied for protection. For readings of extreme precision, a mirrored strip around the scale eliminates parallax errors, and a pointer tip with a knife edge is used.

As an aid in selecting the right gage or replacement part, a legend which gives the gage model number and materials used in constructing the movement, connection, and Bourdon tube is printed on the dial.

The dial scale is usually graduated over a 270-deg arc, which gives a relatively long scale length for the dial diameter. This scale length contributes to readability. The number of graduations usually increases with the accuracy of the gage, Fig. 4, since there is little point in reading values which are more accurate than the gage itself.

Cases: The gage case encloses the gage internals and protects working parts from dust, dirt, and, in some designs, from corrosive atmospheres. In addition, the gage is often mounted on an instrument panelboard, wall, or machine by the case. If a gage is stem mounted, the socket itself supports the gage.

For safety reasons, a solid front wall may be required on the gage to separate the observer from the gage components. Such a wall is usually cast as an integral part of the case, and a weather-tight rubber disc seals the rear section, releasing pressure out the back of the gage if the tube ruptures.

Drawn and cast cases are available in several different mounting styles. Gages can be obtained with flanges on either the back or front of the case and with mounting holes located in accordance with ASA standards, Fig. 5. The back flange style is used for wall or equipment mounting; the front-flange type for flush mounting on a panel.

Drawn-case gages with beaded cases have no flange, and are stem-mounted. Cast cases are not normally available in this style. Hence, a back-flange cast case for stem mounting must be specified.

The turret style is used primarily for wall mounting, but can be obtained with an adapter ring for flush mounting.

Rings: Gage crystals are held against the case front by rings which are classified broadly into two categories: According to appearance, such as beaded, flat, flared, and peaked; and according to methods of attachment to the case, such as friction, slip, threaded, and hinged, Fig. 6.

Crystals: Transparent cover crystals complete the gage assembly. They protect the dial face and pointers from abuse and help to effect the gage seal. Crystals are available in flat glass, beveled glass, cellulose acetate, shatterproof glass, acrylic plastic, and nonelectrostatic plastic.

Selection Factors

Selection of indicating gages is essentially a three-phase approach: 1. General conditions under which the gage must operate are determined. 2. A basic gage type is selected. 3. Unusual conditions which affect various components are specified.

Characteristics of Gage Components

Sockets

Types: *Bar Stock*—Economically used on equipment produced in high volumes. Density of material is equal to that of forged sockets and superior to that of sand castings. Withstands gas pressures to 10,000 psi except in small sizes.

Forged—Used when a quality socket of dense material is required to conform to a particular design shape.

Cast—Used when intricate shapes are required or when the production volume of the equipment is low. Porosity of material limits gages to low and medium-pressure applications.

Materials: Selection depends upon corrosive nature of fluid being measured. Commonly used materials are brass, alloy steel, stainless steel, and K-Monel.

Common Connection: Male type with ¼-in. threads for NPT working pressures up to 800 psi and ⅛-in. NPT threads for pressures above 1000 psi.

Tube Spring Materials

Phosphor Bronze—Grade A: Strength is derived from cold working, and material cannot be heat-treated. Springs of this material are limited to vacuum, compound, and pressure gages up to 800 psi.

Beryllium Copper: Used for pressures from 1000 to 5000 psi.

Type 316 Stainless Steel: Provides corrosion resistance to many chemicals. Cannot be heat-treated to any increased degree of hardness. Tubes are available for pressures up to 10,000 psi. Economically, this material is comparable to alloy steels.

Type 403 Stainless Steel: Can be heat-treated and is suitable for pressures up to 20,000 psi. Tube walls for these pressures are heavier. Corrosion resistance, which is less than type 316, is not a serious factor in many applications.

K-Monel: Corrosion resistant to extremely sour oil or hydrogen sulfide. Used for pressures up to 20,000 psi.

Ni-Span C: Practically unaffected by temperature changes. Effect on calibration is less than ¼ per cent over a range of temperatures from —50 to + 150 F. Used in test gages and diaphragm pressure elements.

Tube Linkage

Tip: Either male or female. Female is preferred because tube walls tend to tighten against tip under pressure, increasing the seal. Male connection works against the seal, since the tube wall tends to pull away from the tip.

Link: A nonadjustable solid bar, or two slotted pieces screwed together so that length can be adjusted. For application in which pressure is released suddenly, use a link for which motion is positive in one direction and is spring tensioned in the other. This eliminates driving the pointer to zero with a large force.

Connection: Soldered, welded, threaded and soldered, or threaded and welded. Soft-solder joints are used for low-pressure applications and for operating temperatures to 150 F. Silver soldering or silver brazing is used for medium pressures, while welding is used for high-pressure applications.

Movement

Sector Tail: When riveted to the link, the sector tail and link assembly resists loosening due to pulsating pressures and vibration. Adjustment of the riveted assembly is made by bending the tail, and hence, is limited by the ductility of the material. When unlimited calibration adjustments are required, use a gage in which the link is fastened to the tail by an adjusting screw.

Plates: When the gage is used under pulsating or high operating pressures, plates with increased thicknesses, or staked plate-bushings, should be used to provide longer bearing surfaces.

Contact Materials: Gages with dissimilar metals, such as phosphor bronze with stainless steel, nylon with stainless steel, and phosphor bronze with nickel silver, for contact surfaces should be used for long life.

Pointers

Fixed Type: For economy, pointer is mounted tightly on pinion shaft. For zero adjustment, liquid column-head compensation, or preloading, pointer hub is lifted from shaft and repositioned.

Adjustable Type: For convenience and precision zero adjustment, pointer is mounted with friction fit between pointer hub and shaft. Adjustment is made by turning hub while holding pointer shaft firmly.

Micrometer Adjustment Type: For refined and easy adjustment. Usually available only on Grade AA gages. Worm and pinion-type drive is mounted on pointer hub. Movement of worm gear causes vernier-like adjustment of pointer position.

Test Gage Type: For precision measurements. The micrometer adjustment is of lighter construction than in the general micrometer type. Instead of the permanent worm gear, a special tool is used to engage teeth on pointer hub for adjustment.

Dials

Materials: Steel, brass, aluminum, solid plastic, or laminated plastic.

Graduations: Major, intermediate, and minor, depending upon length of graduation line. Numerals are placed on major graduations. Number of minor graduations usually conforms to accuracy of gage. For example, 100 psi gage with 1 per cent accuracy has minor graduations 2 psi apart since the gage is accurate to ±1 psi.

Cases

Drawn: Steel is most common and economical material. Select brass cases for corrosion resistance, decorative value, and antimagnetic applications. For limited weight applications, use aluminum cases. Mounting styles include back flange, front flange, and beaded types.

Cast: Cast iron is generally used because of ruggedness. Cast cases of aluminum and brass are selected for the same applications as drawn cases of these materials. Phenolic resin cases provide excellent corrosion resistance. Mounting styles include back flange, front flange, and turret types.

Rings

Beaded: Ring is drawn and does not have flange.

Flat: Has a flat flange which matches the back flange and has some diameter.

Flared: Drawn from sheet metal in the form of a flange which has curved and flared cross section.

Friction: Usually has indentations around circumference for snug fit in case. Holds crystal tight against case, but is difficult to remove, especially if corroded.

Slip: Fits loosely over front of case. Is held in place by screws and is easily removed.

Threaded: Ring is internally threaded to accept a threaded case. Provides dustproof enclosure.

Hinged: Used only on front flanged cases. A clip hooks ring to case at top. A retaining screw locks ring to case at bottom.

Crystals

Flat Glass: Most commonly used type for general applications.

Beveled Glass: Beveled edge fits ring. Used for dustproof and moistureproof applications when cemented to ring.

Cellulose Acetate: Either in flat or curved form. Used in applications where breakage is prevalent.

Shatterproof Glass: Prevents flying glass should tube rupture.

Acrylic: Provides an unbreakable crystal, but is easily scratched or scarred.

Nonelectrostatic Plastic: Prevents buildup of electrostatic charges which can affect pointer position.

The following paragraphs discuss the important factors which should be considered in selecting the right gage. These factors are presented in the order most commonly considered in gage selection. Coupled with the specific information on various components contained in the section *Characteristics of Gage Components*, these general factors provide the information necessary to effectively follow the three-phase approach to gage selection.

Measured Medium: Since the vital measuring element is often exposed directly to the pressurized fluid, many problems may arise if complete information on the specific fluid is not obtained. The fluid may be corrosive, it may solidify in the Bourdon tube at room temperature, or it may contain entrained tars or solids which leave deposits that clog the measuring element or the pressure connection.

The various Bourdon-tube materials available are discussed in conjunction with the *Characteristics of Gage Components*. Clear liquids, or clear gases or vapors can often be handled directly by proper selection of such materials. However, if direct contact of the fluid with the measuring element must be prevented, a number of attachments are available as standard gage accessories. Gages with such attachments are sometimes called chemical gages.

One common method of sealing the gage tube from the measured medium is the diaphragm seal. This seal is a corrugated, corrosion-resistant diaphragm which is tightly clamped between two supporting housings, Fig. 7. The upper housing is tapped and the male gage connection screws di-

rectly into the housing. The Bourdon tube and all space over the diaphragm is filled with a suitable fluid, which hydraulically transmits the measured pressure applied to the lower side of the diaphragm. A variety of such attachments are available to suit the various pressures and fluids. The gage and the attachment should be selected as a unit.

When live steam or hot vapors are measured, direct connection to the Bourdon tube may raise the tube temperature above the recommended level of 150 F. A single-coil siphon, Fig. 7, can be used with a shut-off cock to trap condensate in the line and gage. This arrangement prevents excessive temperature in the Bourdon tube. When the gage is exposed to freezing temperatures, this arrangement can also be used with a low-freezing liquid filling the Bourdon tube and line to the siphon.

Required Range: In considering the required pressure range for a gage, determine if the pressure will be fairly constant within relatively narrow limits, or if it will vary over a wide range. The American Standard recommends a maximum working pressure, under steady pressure,* of not more than two-thirds the maximum value on the scale. Otherwise, accurate indication may not be maintained, and life of the Bourdon tube may be shortened. Thus, if the working pressure is 200 psi, the selected range should be 0 to 300 psi.

In cases of fluctuating pressures, which ASA defines as exceeding the steady pressure limits and having no cyclic regularity of variation, the maximum working pressure should not exceed one-half of the maximum value on the scale. This is a safety factor to prevent permanent set of the Bourdon-tube spring. The actual effect varies with the spring material, extent of fluctuations, and temperature.

When vacuum and pressures above atmospheric

*Pressure with a maximum variation of 1 per cent per second or 5 per cent per minute. Percentage refers to total scale range.

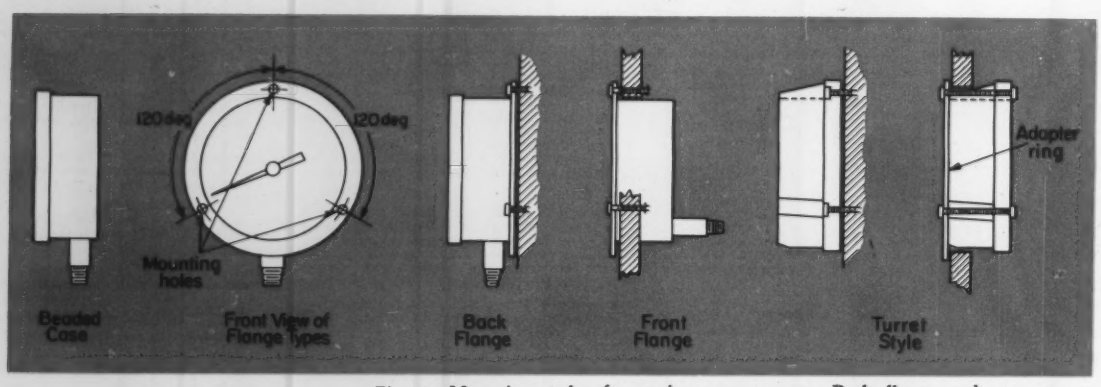


Fig. 5—Mounting styles for various gage cases. Back flange and turret types are generally wall mounted. Front-flange type is panel mounted. Beaded case is stem mounted. Turret style may be flush mounted with adapter ring.

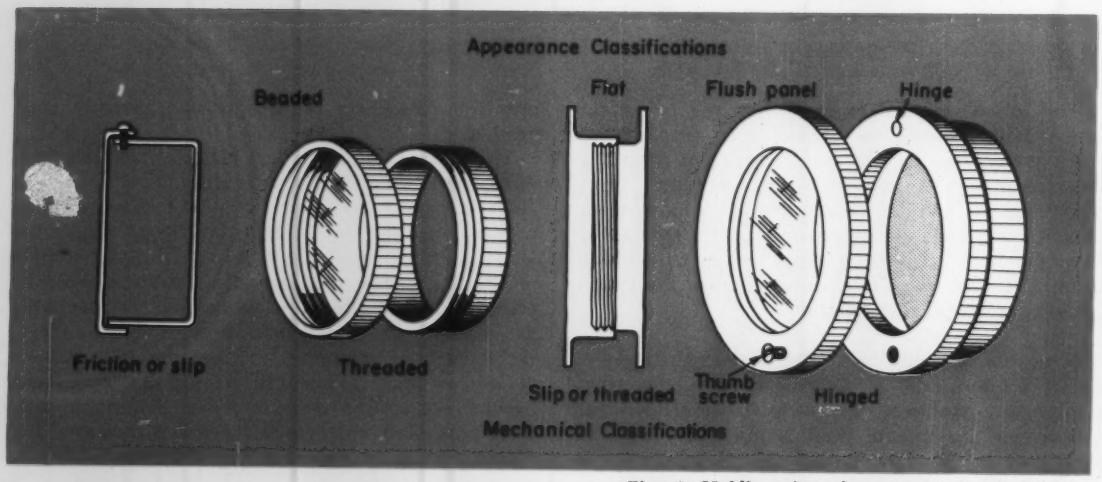


Fig. 6—Holding rings for crystals classified by appearance and mechanical means of attachment.

pressure are anticipated, specify a compound gage. This gage is a standard Bourdon-tube gage with the dial scale graduated in gage pressure on one side of the zero point and vacuum on the other. For use on equipment normally operating under pressure, but subject to both pressure and vacuum, such a gage prevents damage that might otherwise occur in an ordinary gage subjected to a sudden drop to the vacuum side. The reverse is also true for equipment normally operating under vacuum.

If good readability is desired over a relatively small portion of a pressure range, a gage with a relatively long tip travel of the Bourdon tube can be used. The pointer of this type of gage is held at the low value of the range until the pressure exceeds this value. Such an arrangement permits wider graduations over the scale length, and hence, greater readability. This type of gage is said to have a suppressed zero.

When two related pressures are to be indicated on the same dial, a duplex gage should be selected. This gage has two complete measuring systems in one case: Two connections, two Bourdon-tube springs, two movements, and two pointers. These gages are used on air brake systems, water softeners, and filters. Similarly, dial-type gages are available for differential pressures. One pointer indicates the difference in two pressures. The dial for this gage can be graduated with zero at midscale.

Ambient Atmosphere: In many cases, particularly when gages are selected in quantities for original equipment use, very little is known about the atmosphere in which the gage will be installed. However, many component features and specifications for the gage depend upon this knowledge.

The problem is not one of medium inside the tube, but is one of the medium around the gage. Alkali-laden atmosphere, for example, can ruin an aluminum case selected perhaps for light weight. Hence, a gage should either be selected which will operate over wide range of atmospheric conditions, or the end use of the equipment should be specified.

Wear Conditions: Pulsating pressures, sudden shocks, and gage vibration can seriously affect gage accuracy and life. The ASA definition of pulsating pressure is similar to that given previously for fluctuating pressure but is differentiated as having a cyclic regularity of variation. Rapid pulsations cause the gage pointer to oscillate to the point that it is almost impossible to take a reading. In addition, they can cause excessive wear of the gage mechanism and destroy gage accuracy.

The simplest way to minimize the effects of pulsating pressure is to place a shut-off valve in the line to the gage and throttle the valve until the pulsation just disappears. This method, however, invites trouble due to clogging of the very small opening through the valve. Reliable protection against pulsations can be obtained by using a pulsation damper on the gage. A typical type, Fig. 8, employs a diaphragm seal arrangement. Above the seal and inside the Bourdon tube, a nonfreezing

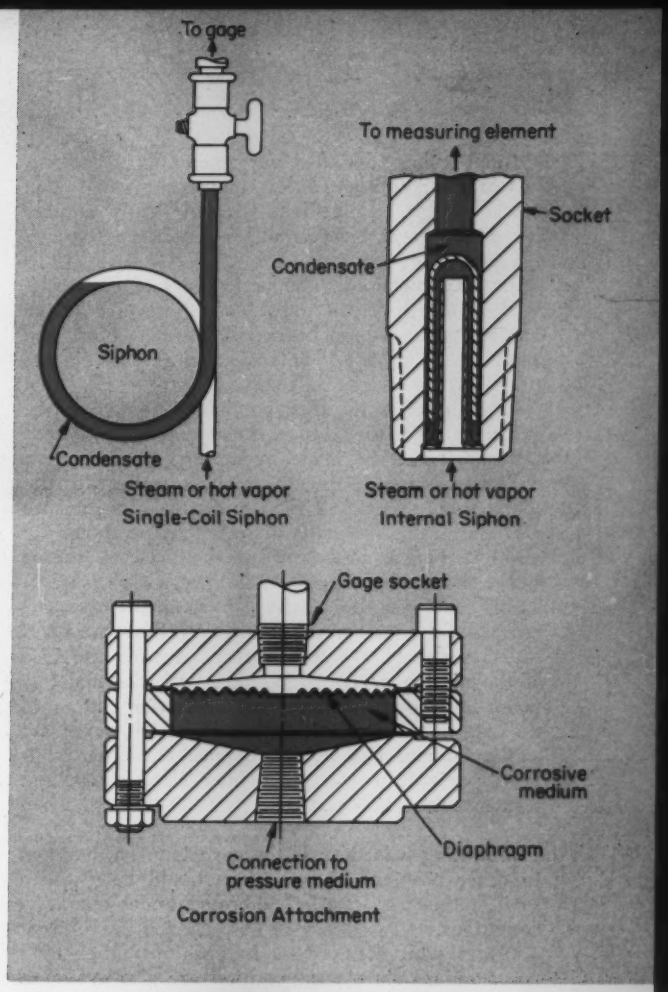


Fig. 7—Gage attachments to protect measuring element from corrosive or high-temperature fluids.

hydraulic oil is used to damp pulsations and permit reading of a mean pressure indication.

Other methods of damping include throttling orifice screws which can be added to the gage socket, piston-type dampers which employ movable piston, and a baffle type with a series of orifices which can absorb pulsations in excess of 1 cps.

Such damping devices also prevent damage to the gage from sudden and large pressure changes. To help prevent damage from shocks, some gages include a zero stop in the movement rather than a dial pin which can cause a bent pointer if pressure is suddenly released.

Most dial indicators are not designed to withstand continuous vibration. Hence, these gages should be protected by suitable cushioning of the mounting, or by firmly attaching the gage to a rigid support and using flexible tubing for the pressure connection.

For use on such equipment as portable air compressors and spravers, where severe mechanical vibration is generally present, heavy-duty gearless gages are available. These gages have extra long

Bourdon tubes, designed for maximum resistance to vibration, and a gearless movement which has direct linkage arrangement without sector or pinion. These gages meet Grade B standards.

Gage Connections: The basic types of gage connections are discussed under *Classification of Gage Components*. Where connections other than the standard ¼ in. or ½ in. male connections are required, adapters are available.

If the gage is installed so that a liquid column will exert a pressure due to the static head of liquid, correction must be made by a zero adjustment on the gage pointer. This adjustment is made with the connecting piping full of liquid and the pressure source shut off. Normally a shut-off valve should be installed in the line between the pressure source and the liquid column. Static heads occur when liquids are measured, when gases or vapors contain condensables, or when corrosion seals are used.

Gages should always be installed with the face of the dial in a vertical position with the midscale point in a perpendicular line with the bottom of the gage. This is the position in which gages are calibrated and designed to operate. In other positions, weight of the parts may affect wear and influence the readings.

Mounting Selection: If the gage is to be mounted in other positions, the position should be specified so that the gage can be calibrated under operating conditions.

Gages with connections in positions other than the standard six o'clock position are also available. The connection position should be specified by the designer so that the dial can be properly made.

Gage Size: The nominal size of the gage is the inside diameter of the case at the face of the dial. Available gage sizes depend somewhat on the type of gage, and are generally related to the degree of accuracy required.

For drawn-case gages, selection is usually limited to dial sizes of 1½, 2, 2½, 3½, and 4½ in. In all of these sizes for a given range, the value of the smallest graduation is the same, as established by ASA standards.

Readability and accuracy do not basically influence the selection of drawn-case gage sizes. However, relatively large numerals on large size dials do ease the readability where, for example, there are physical limits on how close the observer can approach the gage to read it. More pertinent are the limitations placed on space for equipment or panels.

For Grade A and Grade AA gages, commonly available in sizes over 4½ in., the values of the smallest graduations do vary somewhat with size. In general, gages 8½ in. and smaller have one set of limits and gages larger than 8½ in. have another. These values are closely related to the guaranteed accuracies of the gages.

Little is gained by insisting on finer gage graduations than are compatible with the accuracy of the gage. For example, with a Grade B gage (2 per cent accuracy over midscale) which has a range of 0 to 600 psi, readings accurate to within 12 psi of the true value can be obtained. However, actual minor graduation limits for this range are 10 psi. To specify smaller divisions would mislead persons reading the gage.

Required Accuracy: Accuracy is generally expressed in terms of per cent of scale range. It should never simply be expressed in per cent without the qualification.

The degree of accuracy specified depends upon the conditions of service, actual need for precise readings versus trend indications, and probable maintenance care to sustain the accuracy. As a general rule, the more rugged the service, the greater the compromise between accuracy and costs.

An often misunderstood aspect of stated gage accuracies is the fact that the degree of error is the maximum guaranteed by the manufacturer. This means that the gage will not exceed an error of, for example, 2 per cent of scale range. The actual accuracy may well be better than this value at working pressure. The gage can be calibrated to determine the actual accuracy. However, such calibrations do not assure sustained accuracy.

Related to accuracy is the characteristic of reproducibility or consistency of readings. This is the ability of the gage to give the same reading for same applied pressure time after time. Consistency may be more important than the actual accuracy if the only purpose of the gage is to tell an operator when to push a button or shut off a machine.

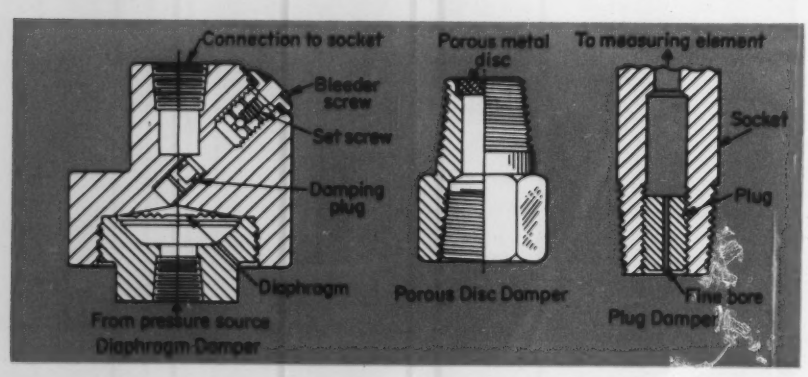


Fig. 8—Pulsation dampers to protect gage elements from harmful variations in pressure build-ups.

A cam shaft acts like a torsion spring. If ignored, shaft "wind up" can spoil intended cam action. Malfunction or early failure are the hazards. One way to be safe is to examine . . .

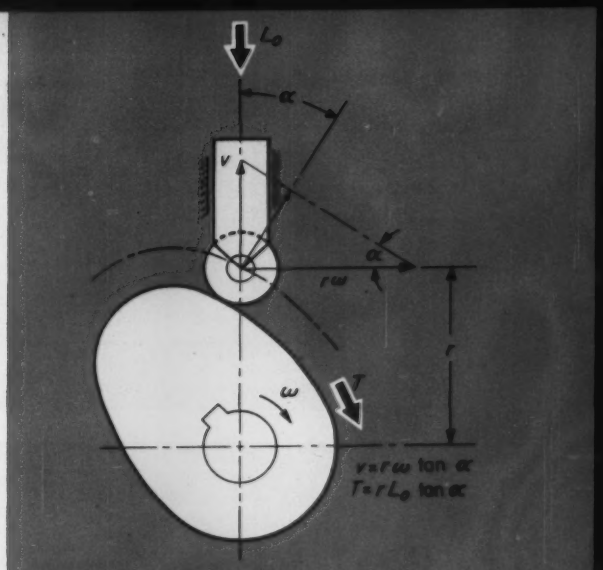


Fig. 1—Torque and velocity relationships in a typical cam-and-follower system.

cam torque curves

HAROLD A. ROTHBART
Associate Professor of Mechanical Engineering
The City College
New York, N. Y.

WHAT happens in a cam and follower system as the cam shaft winds up and unwinds under load?

High-speed movies, as well as actual machine performance in extreme cases, tell the story. The power-input end of the cam shaft generally turns at nearly constant speed. Speed of the cam itself is reduced as it twists, up to the instant of maximum torque. During this period, the follower moves slower than intended.

Beyond the instant of maximum torque, energy stored in the shaft is released and drives the cam at an increasing speed. Follower velocity and acceleration rise above values dictated by the profile of a constant-speed cam.

In the region of maximum rise, a spring-loaded follower may jump off the cam. The spring is not strong enough to offset the effect of shaft wind-up. Sometimes a positive-drive cam exhibits impact in the same range.

High-speed movies show that the cam appears to stand still and then snap free at the end of the stroke. Reluctant to move at first, the follower mass catches up with the forcing cam action and then overshoots it.

This problem is most likely to arise wherever any one of these factors is present:

1. Heavy masses or loads, as in indexing turret mechanisms.
2. High inertia loads and large pressure angles.
3. Spring shafts, as in computers.

Torque transmitted by the cam is a measure of how severe the problem is likely to be. Besides telling how the cam shaft will be loaded, transmitted

Nomenclature

a = Follower acceleration, in. per sec^2
E = Energy in torsional system, lb-in.
h = Maximum rise of follower, in.
K = Torsional spring constant, lb-in. per rad
L = External load on cam, including spring load, lb
L_o = Total load on cam, including external load, inertia, etc., lb
m = Mass, lb-sec^2 per in.
r = Radial distance to center of roller follower, in.
T = Torque, lb-in.
v = Follower velocity, in. per sec
y = Follower displacement, in.
α = Cam pressure angle, deg
β = Cam rotation for total event, rad
γ = Angle of twist, rad
θ = Cam rotation for displacement y, rad
ω = Cam rotational speed, rad per sec

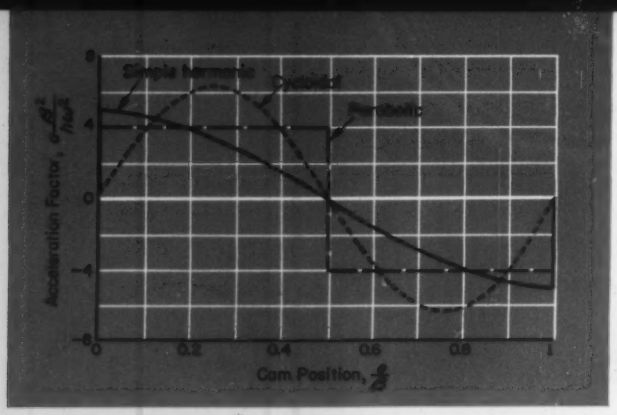
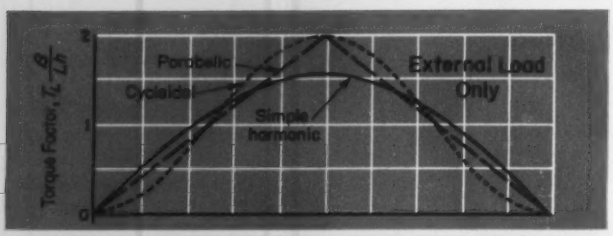


Fig. 2 — Acceleration curves of three conventional cam profiles.



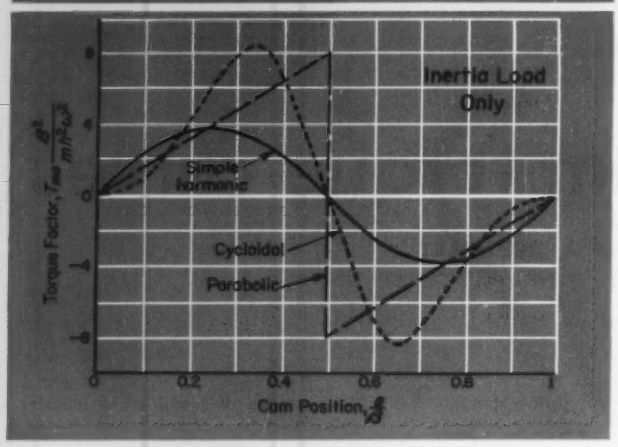


Fig. 3—How external load and inertia load affect transmitted torque for three profiles.

torque indicates power required to drive the system. Therefore, study of torque curves can be doubly helpful.

Finding Torque: For simplicity, assume that a cam is driving an in-line translating roller follower, Fig. 1. From the equations in Fig. 1,

$$T = \frac{L_o v}{\omega}$$

Total load L_o is made up of external load L and inertia load ma. Then,

$$T = \frac{(L + ma)v}{\omega}$$

Torque curves can be plotted for successive cam positions by solving this equation. All terms are dictated by the proposed design. Follower acceleration a and velocity v depend, of course, upon the selected cam profile.

Comparing Profiles: To show how different profiles affect transmitted torque, three common profiles are compared here: The so-called parabolic, simple-harmonic, and cycloidal, Fig. 2. In recent years, these profiles have been investigated and compared many times for dwell-rise-dwell cams. They have been checked for such properties as acceleration, impact, and vibration. But, rarely has torque been the criterion.

Generally, the cycloidal profile has won favor because of its continuous acceleration curve. Although having lowest maximum acceleration of the three, the parabolic profile has lost favor because of its abrupt acceleration changes. The simple-harmonic profile is intermediate. It provides "smooth" acceleration except for finite, instantaneous changes at the beginning and the end of rise. Also, its maximum acceleration falls between maximum values of the parabolic and cycloidal profiles.

Torque curves are plotted in Fig. 3 for the three profiles for two different design conditions:

1. Inertia load ma is negligible compared to external load L (slow speed).

Table 1—Cam Equations

Factor*	Cycloidal	Simple Harmonic	Parabolic $\frac{\theta}{\beta} \le 0.5$	Parabolic $\frac{\theta}{\beta} \ge 0.5$
Displacement $y(l/h)$	$\frac{1}{\pi}\left(\pi\frac{\theta}{\beta} - \frac{1}{2}\sin 2\pi\frac{\theta}{\pi}\right)$	$\frac{1}{2}\left(1-\cos\pi\frac{\theta}{\beta}\right)$	$2\left(\frac{\theta}{\beta}\right)^2$	$1-2\left(1-\frac{\theta}{\beta}\right)^2$
Velocity $V(\beta/h\omega)$	$1-\cos 2\pi\frac{\theta}{\beta}$	$\frac{\pi}{2}\sin\pi\frac{\theta}{\beta}$	$4\frac{\theta}{\beta}$	$4\left(1-\frac{\theta}{\beta}\right)$
Acceleration $a(\beta^2/h\omega^2)$	$\pi\sin 2\pi\frac{\theta}{\beta}$	$\frac{\pi^2}{2}\cos\pi\frac{\theta}{\beta}$	4	-4
External-Load Torque $T_L(\beta/Lh)$	$1-\cos 2\pi\frac{\theta}{\beta}$	$\frac{\pi}{2}\sin\pi\frac{\theta}{\beta}$	$4\frac{\theta}{\beta}$	$4\left(1-\frac{\theta}{\beta}\right)$
Inertia-Load Torque $T_{ma}(\beta^3/mh^2\omega^2)$	$2\pi\left(\sin 2\pi\frac{\theta}{\beta} - \frac{1}{2}\sin 4\pi\frac{\theta}{\beta}\right)$	$\frac{\pi^3}{8}\sin 2\pi\frac{\theta}{\beta}$	$16\frac{\theta}{\beta}$	$-16\left(1-\frac{\theta}{\beta}\right)$

*Factors are nondimensional. Actual acceleration for the cycloidal profile, for example, is obtained by transposing terms: $a(\beta^2/h\omega^2) = \pi\sin 2\pi\,\theta/\beta$, or $a = (h\omega^2\pi/\beta^2)\sin 2\pi\,\theta/\beta$.

2. External load is negligible compared to inertia load (high speed).

As an example, torque transmitted by the cycloidal profile is calculated this way: Adapt earlier equations to external load only:

$$T_L = \frac{Lv}{\omega}$$

The equation for velocity v is given in Table 1. Then,

$$T_L = \frac{Lh}{\beta}\left(1-\cos 2\pi\frac{\theta}{\beta}\right)$$

For plotting in Fig. 3, this equation is converted to a nondimensional form:

$$T_L\frac{\beta}{Lh} = 1-\cos 2\pi\frac{\theta}{\beta}$$

For inertia load only,

$$T_{ma} = \frac{mav}{\omega}$$

$$= \frac{2\pi mh^2\omega^2}{\beta^3}\left(\sin 2\pi\frac{\theta}{\beta}\right)\left(1-\cos 2\pi\frac{\theta}{\beta}\right)$$

Simplified and converted to nondimensional form for plotting in Fig. 3, this equation becomes

$$T_{ma}\frac{\beta^3}{mh^2\omega^2} = 2\pi\left(\sin 2\pi\frac{\theta}{\beta} - \frac{1}{2}\sin 4\pi\frac{\theta}{\beta}\right)$$

The curves for the three profiles in Fig. 3 show some revealing comparisons. For the same external load, the simple-harmonic profile transmits only about 80 per cent of the torque imposed upon either the cycloidal or the parabolic. For the same inertia load, the simple harmonic shows torque of about 50 per cent that of the cycloidal or harmonic. In actual designs, the figure would lie somewhere between 50 and 80 per cent, depending upon the relative magnitudes of external and inertia loads.

Energy: Another way to look at the problem is to examine the energy stored in the cam shaft.

In a torsional system, the stored energy is $E = \int T d\gamma$. Torque $T = K\gamma$ and $d\gamma = dT/K$. Therefore, the energy at any instant is

$$E = \int\frac{T}{K}dt = \frac{T^2}{2K}$$

Hence, stored energy is proportional to the square of torque. Or, for external load only, the energy stored in a simple-harmonic system is about 60 per cent of that in the cycloidal or parabolic. For inertia load only, it is only 25 per cent.

Suggestions: Implications for design are obvious. To minimize shaft wind-up, use huskier machine members, especially shorter and larger-diameter drive shafts. Also, include torque as a criterion in the selection of profile.

ACKNOWLEDGMENT

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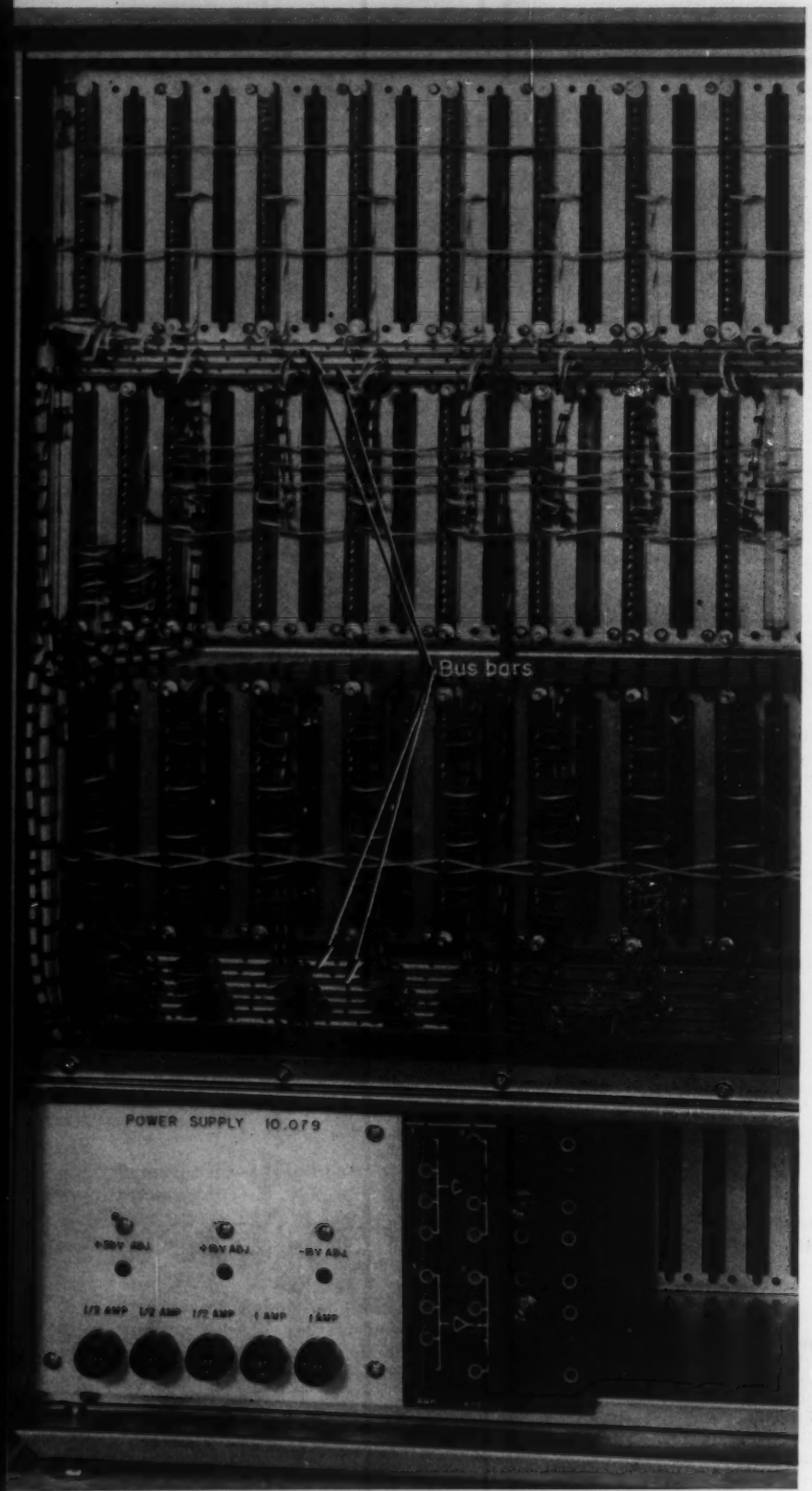
Conference Transactions

Transactions of the Fifth Conference on Mechanisms (239 pages), containing the 19 papers presented, are available at $3.00 each from Reader Service Dept., **Machine Design**, Penton Bldg., Cleveland 13, Ohio.



Bus Bars in

COMPLEX CABLING IS MINIMIZED in the design of a new transistorized analog computer by applying a multiple bus-bar power-distribution system. Six bars, each approximately 15 in. long, are mounted directly above the regulated power supply of the computer. Voltages on three of these bars are +30 v, +15 v, and −15 v. The fourth bar serves as a regular plus-and-minus ground; the fifth bar as a high-quality ground; and the remaining bar as a spare.

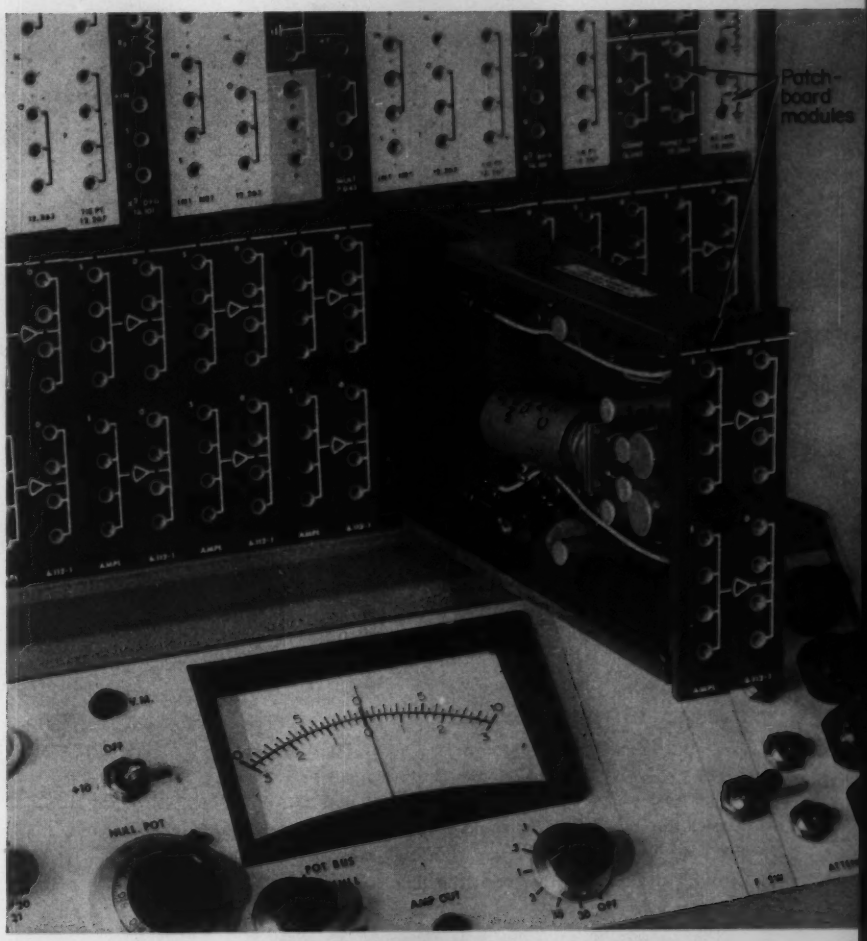
In the top half of the computer is a group of three more bus bars. One supplies a reference voltage of +10 and another −10. The third serves as a high-quality ground.

In the bars are a series of tapered holes for electrical connection every ½ in. along their length. Built-in connectors for each plug-in computing element are wired directly to the bus bars.

Portable Computer Simplify Wiring-System Design

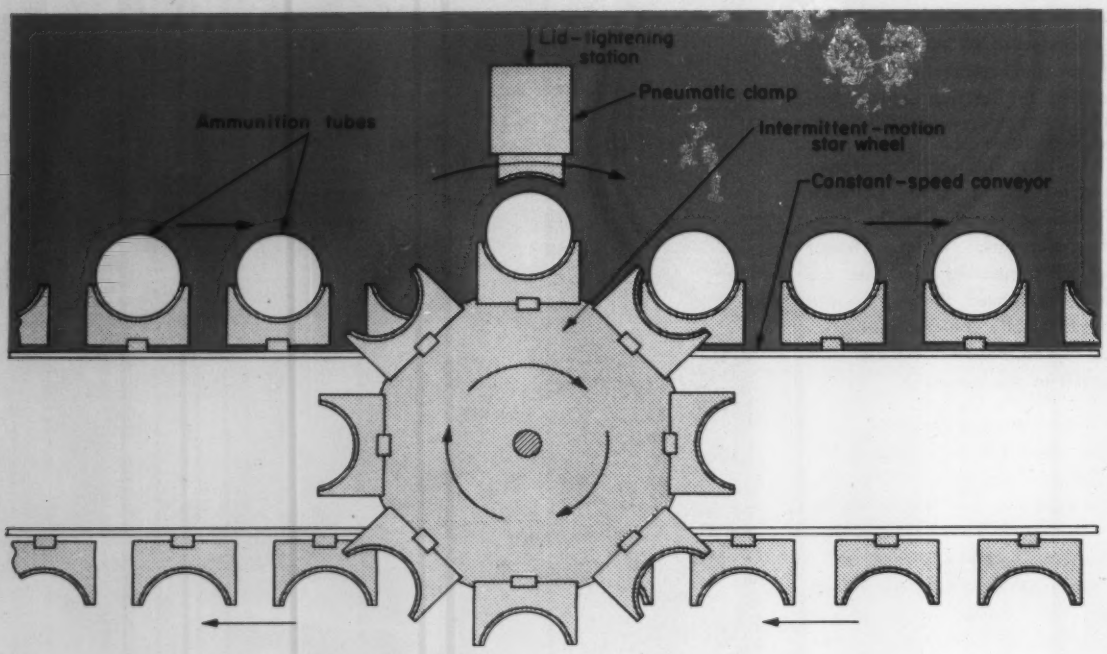
COLOR-CODED PATCHING MODULES are designed as an integral part of each plug-in computing element, according to designer James Patmore, Electronic Associates Inc., Long Branch, N. J.

This design approach completely eliminates wiring cables between the patching panel and the computing elements. When different types of computing elements are added or removed, the patch-board is automatically changed and is an exact representation of the elements plugged in the computer.



COOLING IS NO PROBLEM with this desk-top size computer since it is fully transistorized. The solid-state design draws less power than a 60-watt lamp.

Continuously Moving Parts

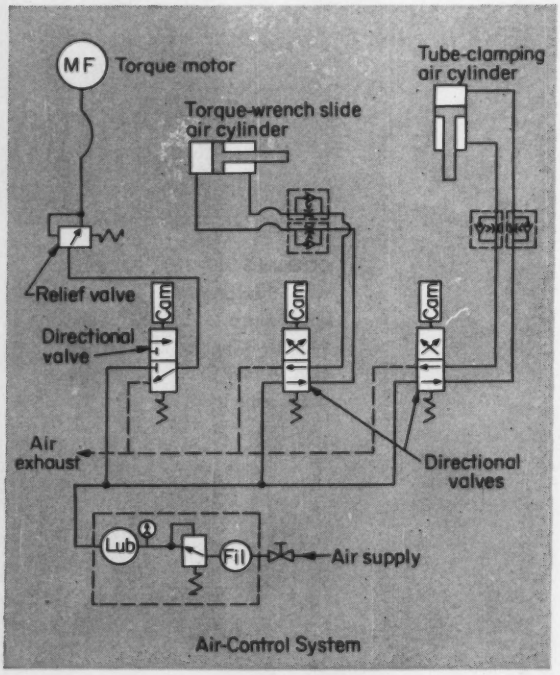


STAR-SHAPED WHEEL lifts parts from a conveyor and stops them momentarily, even though the conveyor runs at constant speed. The star wheel, which resembles a ferris wheel, is mounted between the two conveyor-chain tracks. Motion of the star wheel is intermittent, but is synchronized through a Geneva drive with the linear motion of the conveyor.

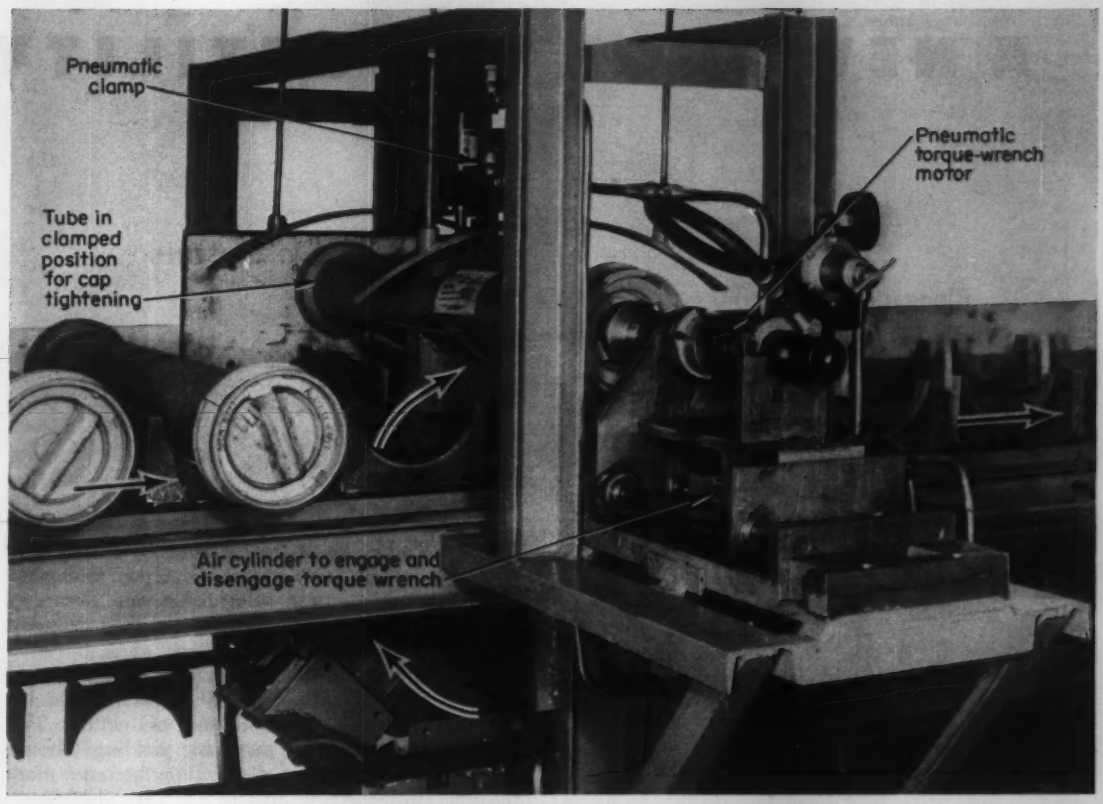
The automatic machine was designed by the Navy's Ammunition Loading Production Engineering Center, Crane, Ind., to tighten covers on aluminum tubes containing ammunition. Anchor Steel and Conveyor Co., Dearborn, Mich., built the machine.

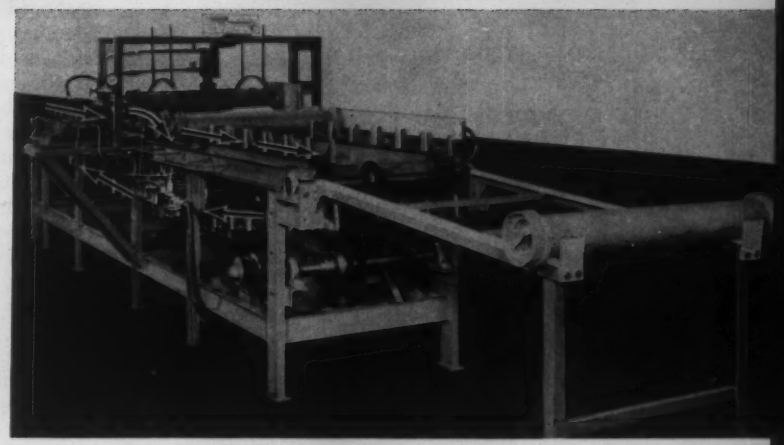
CLAMPING AND TIGHTENING operations are performed by pneumatically powered devices. When each tube reaches the top-most position of the star-wheel rotation, the star wheel stops and an air cylinder clamps the tube in place. Next a pneumatic torque wrench advances, rotates the cap on the tube, and retracts. The clamp cylinder retracts and the star wheel indexes.

Cam-actuated pneumatic directional valves sequence the clamp and torque-wrench movements in synchronization with the conveyor.



Dwell on Ferris Wheel


Pneumatic clamp
Tube in clamped position for cap tightening
Pneumatic torque-wrench motor
Air cylinder to engage and disengage torque wrench



OPERATING CYCLE BEGINS when a metal tube is manually placed into a pair of carriers which serve as a cradle. When the tube reaches the star indexing wheel, it is lifted off its conveyor cradle and indexed into a clamping position.

The Geneva drive allows the star wheel to dwell long enough for the tube to be clamped securely in position and its cover tightened. The tube is indexed back into a cradle on the chain conveyor, and a tube immediately behind is indexed into the clamping and tightening position. The chain conveyor delivers the tubes to an inclined-ramp unloading station.

A NEW LOOK AT DUCTILITY

MICHAEL V. ZAUSTIN*
Pasadena, Calif.

Elongation and reduction are no criteria of ductility. They vary with the dimensions and shape of a test specimen and thus are not fundamental properties of metals.

A new method for evaluating ductility presented here is based on shear resistance and cohesion of the material and is, therefore, independent of the shape and size of the specimen.

This method gives quantitative data for design and makes it possible to represent ductility graphically. It can be used to predict whether a metal will behave in a brittle or ductile manner, what the degree of ductility is, and what possible type of fracture can occur in an element subjected to combined stresses.

DUCTILITY is, in many respects, a very important property of metals. Upon it depend the strength and safety of design elements, the ability of metals to be formed, and their capacity to resist stress concentrations.

If a stress concentration appears in a ductile metal as shown in Fig. 1*a*, the peaks of stresses do not develop as they would in the absence of ductility. The stresses are lowered due to plastic yielding (shown in black), and the stress distribution becomes more uniform. Thus, the resistance of a structural element, weakened by a stress raiser, is restored to a considerable degree. A similar situation develops in cases of bending or any other nonuniform stress distribution, Fig. 1*b*.

This ability for local yielding and equalization of stresses is a kind of self-healing property of ductile metals. In the case of brittle metals, minute cracks and scratches do not cure themselves by plastic yielding but concentrate large stresses at their bottoms. Since the radii at the bottom of the cracks are of atomic order, the cracks propagate relatively fast.

In case of misalignment or other defects of assembling, such as often occur in statically indeterminate structures, ductile metals adjust themselves without ill effects on the structure.

It is well known that metals with a perfect crystal structure are several hundred times stronger than the engineering metals. Technical metals are considerably weaker than theoretical because of the presence of foreign atoms, vacant atomic spaces, and

*Former research engineer, California Institute of Technology, and chief mechanical engineer, California Shipbuilding Corp.

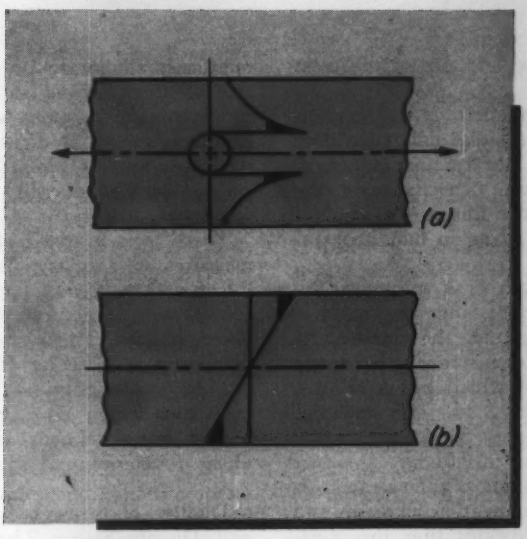


Fig. 1—Stress concentrations in a ductile material. In both specimens, stress peaks are lowered due to plastic yield of the material. Thus, resistance of structural elements to stress concentrations is restored to a considerable degree.

other defects of structure. Thus, all failures of metals are due to structural imperfections.

If a ductile metal is subjected to a stress, the imperfect points of the metal team up with the perfect ones in the process of dislocation, and the result is a kind of average resistance. But if a brittle metal is under a sufficiently large stress, a crack may start at any point. This is why the scatter of experimental data is greater and the reliability much smaller for brittle materials than for ductile materials. Furthermore, fracture of brittle metals starts on the surface while fracture of ductile metals, if it occurs, starts inside. However, the possibility is much greater that external defects will occur rather than internal defects. This fact again contributes to the unreliability of brittle materials.

Why New Methods for Evaluating Ductility Are Needed: The classical methods for evaluating ductility of metals, i.e., by measuring relative elongation and reduction in cross-sectional area, are not satisfactory for several reasons. In the first place, these criteria do not agree with each other. Metal A may be more ductile than metal B when evaluated by relative elongation and less ductile when evaluated by relative reduction.

If metals are arranged in order of increasing ductility, using in one case elongation as a criterion and in another case reduction of area, a different order results. This indicates that elongation and reduction are not fundamental properties of metals. Indeed, relative elongation depends mostly upon the length of the test bar while reduction in area de-

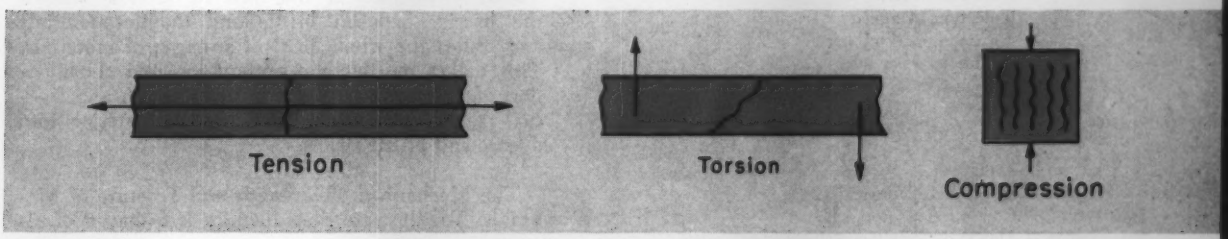


Fig. 2—Failure of a brittle material along planes of maximum tensile stress. In tension, *a*, planes are perpendicular to the axis of the specimen, in torsion, *b*, planes are at 45 deg to the axis, and in compression, *c*, planes are parallel to the compressive force.

pends greatly upon the shape and size of the cross section.

Only when lateral deformation (reduction) is uniform along the specimen, relative elongation does not depend upon gage length. But if a neck is formed, relative elongation at fracture depends upon the geometry of the specimen. Yet this is the kind of information which is usually given in handbooks as a criterion of ductility.

The shorter the gage length of a specimen, the greater the relative elongation; and the more a cross section deviates from round, the smaller the relative reduction. Consider, for instance, a bar made of aluminum alloy 2024S-T4 which has a relative elongation of 16 per cent in 2 in. This material has a relative elongation of only 5 per cent in 100 in. and more than 40 per cent in 0.01 in.

Also, when the concentration of an element is increased in solid solutions, elongation increases and reduction decreases. This indicates that these criteria reflect different physical properties of alloys.

If elongation of solid solutions is greater than that of pure metals, and reduction is greater in pure metals than in solid solutions, the question arises of which are more ductile—pure metals or solid solutions? Obviously, the answer depends upon the selection of the criterion of ductility. It follows, then, that a more reliable measure of ductility is needed.

From the standpoint of design, an elongation value is applicable only when the element is geometrically similar to the test bar. However, reduction of area, derived at the most deformed part of the specimen, is more suitable as a technological criterion. Again, it depends upon the geometry of the cross section. Round specimens give an exaggerated idea of ductility when compared with flat specimens.

These facts discredit elongation and reduction as measures of ductility. Yet, the ability to evaluate this property is very important to a designer concerned with structural elements subjected to combined stresses. These stresses have the property of increasing or reducing ductility. Such an evaluation can be made only on the basis of fundamental properties which do not depend upon dimensions of the test specimens or on the type of loading. Shear resistance and cohesion are such properties.

Duality of Stresses and the Concept of Brittle and Ductile States: Theoretical metallurgy distinguishes two kinds of reactions of metals to external forces: Resistance to shear, and resistance to cohesive separation or tearing apart. On the other hand, the theory of strength of materials proves that the effect of any combination of external forces acting upon a solid body may be reduced to a maximum shear and maximum normal stress. The shear stress is opposed by the shear strength of the material, and the normal stress is opposed by its technical cohesive strength.*

Ductile materials are those which yield to maximum shear stress before maximum normal stress reaches the value of cohesive resistance. Conversely, brittle materials are those whose cohesive resistance is overcome by normal stress before plastic yielding begins. Thus, ductility is not a constant physical property but only a physical state. It is a result of a combination of properties of a material and properties of stresses applied to this material. These properties are inseparable, and the effect of a stress system on ductility is often greater than the effect of chemical composition or heat treatment. Unfortunately, this effect is often overlooked, and its neglect leads to dangerous design errors, especially in the selection of materials for components subjected to combined stresses.

The importance of considering the effect of a stress system on ductility is that such an outlook removes the barrier between brittle and ductile materials and unites the whole field of strength of materials. This makes possible the explanation and classification of phenomena related to deformation and fracture of materials without dividing the materials into ductile and brittle types.

The Mechanism of Strength and Fracture of Materials: To illustrate that ductility is a matter of re-

Nomenclature

A	= Area of test specimen
D	= Diameter of specimen at smooth part
d	= Diameter of specimen at notch
L	= Gage length of specimen
m	= Margin of ductility
S	= Technical cohesive strength (resistance of material to tearing apart)
T	= Resistance of material to shear
α	= "Coefficient of softness" (ratio of maximum shear stress to maximum normal stress)
β	= Coefficient of notch effect
δ	= Total elongation
ε	= Elongation
γ	= Elongation ratio
ψ	= Reduction of area
σ	= Maximum normal stress
τ	= Maximum shear stress
μ	= Poisson's ratio

Subscripts

av	= Average
coh	= At cohesive strength level
$conc$	= Concentrated at notch
max	= Maximum
n	= At notch in specimen
s	= At smooth part of specimen
un	= Uniform

*Cohesive resistance, as considered here, is not the molecular strength. Rather, it represents the average value of the forces of cohesion for the entire mass located at the cross section of the specimen. It can be thought of in the same way that yield strength is considered the average resistance to slip.

lationship between properties of stresses and properties of materials, consider a material which behaves in a brittle manner. Such materials (marble, cast iron, chalk, or some nonferrous alloys, for example) break on planes of maximum tensile stress. In tension the planes are perpendicular to the axis of the specimen, in torsion they are at an angle of 45 deg to the axis, and in compression the planes are parallel to the compressive force provided friction between the specimen and plates of the press is reduced, Fig. 2.

If additional forces are applied to increase the shear stresses as shown in Fig. 3, the same brittle specimens will behave in a ductile manner and will fail in shear. The tensile specimen will extend plastically and form a neck under additional lateral pressure, the torsion specimen will fail in a plane perpendicular to its axis under additional compressive force, and the specimen in compression will fracture diagonally if friction forces between the specimen and press are sufficiently large to reinforce the resistance of the specimen to (Poissonian) tension. The shear stress will overcome the shear resistance first along the diagonal planes.

The same types of fracture are obtained if ductile materials are used without additional shear stresses, Fig. 4. This is because resistance of these materials to shear is less than their resistance to cohesive separation. As limit cases for the relationship between stresses and strengths, examples of brittle fractures of ductile materials under biaxial and triaxial tension, and ductile deformation of brittle materials under biaxial compression and tension, are cited in reference.

Consider a tank under internal pressure and subjected to axial tension. In such a case, relatively small shear stresses, $(\sigma_1 - \sigma_2)/2$, and large normal stresses, σ_1 and σ_2, are present. The result is that such a tank made of reasonably ductile aluminum alloy 7075S-T4, for example, will shatter into fragments. On the other hand, hydrostatic lateral pressure and tension can create a large shear stress and cause a marble specimen to flow like a ductile material.

No matter how simple the loading, shear and normal stresses always coexist, but the proportion depends on the type of loading. Thus, in tension, the maximum shear stress is equal to half of the maximum normal stress, in torsion it is equal to the normal stress, and in compression it is twice as large as the normal stress. This explains the different behavior of materials under different types of loading. For instance, high-strength steels, which are almost brittle in tension, exhibit reasonable duc-

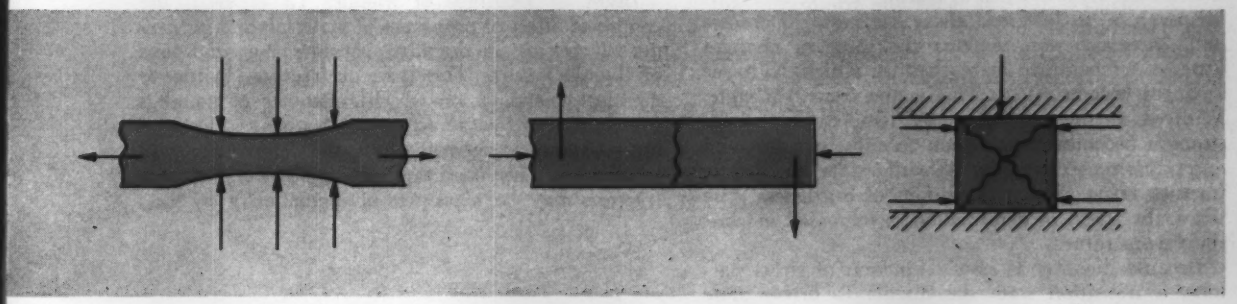


Fig. 3—Results of increasing shear stresses on the specimens of Fig. 2. These brittle specimens now behave in a ductile manner and fail in shear.

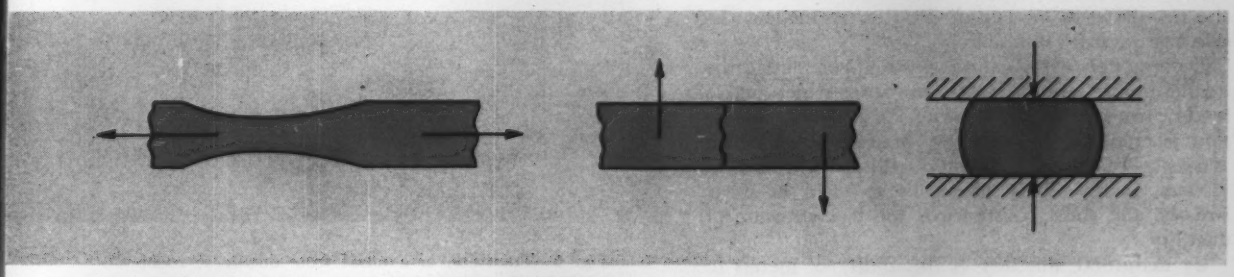


Fig. 4—Types of fracture of ductile materials without shear stresses. Behavior of specimens is similar to that of brittle specimens, Fig. 3, under additional shear.

tility in torsion and still better ductility in compression.

The Nature of Strength and Ductility: The physical nature of strength and ductility of metals is better understood if viewed in the light of the duality of their properties. The usual tensile tests which are the principal tools for investigating mechanical properties of metals, cannot reveal the true nature of strength and deformation or explain the important phenomena of ductility and brittleness. The reason is that tensile strength is not an elementary property but a combination of shear and cohesive strength, the proportion of which is not clearly revealed by tensile tests. Also, these strengths are governed by different laws. Shear strength follows laws similar to those of fluid dynamics. It decreases with increasing temperature, increases with increasing speed of deformation, and depends upon geometric conditions (stress pattern). On the other hand, cohesive strength is practically independent of these factors but depends on chemical composition and crystalline structure.

Only by separating the variables involved in the strength of metals is it possible to arrive at a clear understanding of the phenomena involved in their resistance to deformation. Take, for example, the phenomenon of transition from a ductile to brittle state when the temperature is lowered. If a metal is ductile at room temperature, its resistance to shear is less than its resistance to tearing, Fig. 5. But if its temperature is lowered, shear resistance increases and, since cohesion remains the same or changes little, a temperature is reached at which both resistances become equal. This is the transition state. With a further decrease in temperature, shear strength becomes greater than cohesive strength and a condition necessary for a brittle state and brittle fracture exists. Similar conditions of brittleness arise when the speed of deformation is increased at constant temperature.

Because ductility is also a function of stress pattern, a transition from the ductile to brittle state occurs at a higher temperature when a specimen is tested in tension than when tested in torsion or compression. All these facts clearly suggest the close relationship between the stress system and the behavior of materials under stress. They also indicate the necessity for measuring ductility to include the effect of the stress combination.

Deformation alone cannot describe completely the ductile properties of a metal. The stress which makes it flow must also be known. Fortunately, ductile flow is produced by tangential or shear stress which is easily calculated. Thus, ductility, in terms of stresses, is the ability of metals to yield to shear stresses, and shear resistance is the true measure of ductility.

By definition, ductility is the ability of metals to deform without breaking. Therefore, if S denotes the resistance of a material to tearing apart and T denotes resistance to shear, the ratio T/S expresses the degree of ductility. Indeed, when $T < S$ the material tends to be ductile and when $T > S$ it tends to be brittle. Actually, the behavior of a metal under stress also depends upon the ratio of the maximum shear stress to the maximum normal stress, or $(\tau_{max}/\sigma_{max}) = \alpha$.

The value of maximum shear stress, τ_{max}, determines the possibility that a plastic deformation might occur and, if the load is increasing, the possibility of shear fracture. The value of maximum normal stress, σ_{max}, determines the possibility of tearing apart or brittle fracture. Assuming that at a given state of stress $\alpha = (\tau_{max}/\sigma_{max}) > 1$ or $\tau_{max} > \sigma_{max}$, if τ_{max} reaches the value τ_{yp} before σ_{max} reaches σ_{coh}, ductile deformation will prevent brittle fracture.

With the increase of α, the relationship between τ_{max} and σ_{max} becomes more and more favorable for development of plastic deformation. In such a case, the state of stresses becomes "softer" and, conversely, if α is decreasing, the combination of stresses becomes "harder." Thus, stresses, like metals, may be soft and hard.

From the above follows an important conclusion: Ductility is not a matter of individual strengths or stresses but of ratios T/S and τ_{max}/σ_{max}. The following shows the necessary relationship between these two ratios to insure ductile deformation of a given metal under a given combination of stresses.

Index of Ductility of Metals: To establish the combined effect of properties of materials and properties of stresses on ductility, consider the conditions of ductile failure. The type of fracture, brittle or ductile, depends upon which resistance of metal is overcome first by the corresponding stress. If shearing resistance is overcome first, the deformation will be ductile. This condition of ductility and ductile fracture may be expressed mathematically by τ_{max}

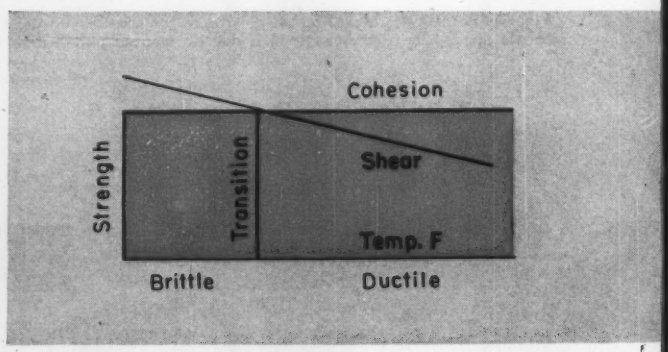


Fig. 5—Transition of a metal from ductile at room temperature to brittle at lower temperatures. Shear resistance increases with decreasing temperature but cohesion remains practically the same.

$= T$ and $\sigma_{max} < S$. Therefore, $(\tau_{max}/\sigma_{max}) > T/S$ or $(\tau_{max}S/\sigma_{max}T) > 1$.
Also,

$$\frac{\tau_{max}\,S}{\sigma_{max}\,T} = 1 + m$$

where m is the margin of ductility since the condition

$$\frac{\tau_{max}\,S}{\sigma_{max}\,T} = 1$$

is on the boundary of ductility and brittleness.

Graphical Representation of Ductility: Since the ratio τ_{max}/σ_{max} is constant for each type of loading, it may be represented by a line *OC*, Fig. 6, with slope τ_{max}/σ_{max}. For tension, tan $\tau_{max}/\sigma_{max} = \frac{1}{2}$. Line *OA* is equal to cohesive strength, and *OD* equal to yield strength in shear. The line of yield strength is intersected first by the line of tension resulting in ductile tensile failure. Segment *BC* or angle *BOC* represents the measure of ductility. It is the amount through which the line *OB*, representing the pattern of stresses, could be rotated before it intersects the line of cohesive strength indicating brittle fracture.

Thus, for each type of stressing there is a different value of ductility. For ductility in tension, the ratio T/S must be less than $\frac{1}{2}$. For torsion it must be less than 1 and for compression less than 2.

This method for evaluating ductility is advantageous because it is based on the most elementary properties of metals and, therefore, is independent of shape and size of specimens. It gives quantitative data applicable in design. Knowing the shear and cohesive strengths of a metal, the designer can determine if a material under a given loading will behave in a ductile or brittle manner. He can also determine the degree of ductility, or the stress under which the member will fail, and the type of possible fracture. Graphically, it is represented by the segment *BC* in Fig. 6. This simple theory of ductility explains many cases of brittle fractures of "ductile" metals.

Properties and the Coefficient of "Softness" of the Stressed State: Any state of stress produced in part by a load changes little during the process of loading. The initial type of stress pattern preserves its character regardless of the magnitude of load. For instance, no matter how much a tensile load is increased, the ratio of shear stress to normal stress remains 1 to 2. This fact justifies the use (as a characteristic of the state of stress) of the "coefficient of softness," $\alpha = \tau_{max}/\sigma_{max}$.

In cases of triaxial combined stresses when $\sigma_1 > \sigma_2 > \sigma_3$, the maximum normal stress expressed by $\sigma_{max} = \sigma_1 - \mu\,(\sigma_2 + \sigma_3)$, where μ is Poisson's ratio. Maximum tangential stress is $\tau_{max} = (\sigma_1 - \sigma_3)/2$ and the coefficient of softness of stresses

$$\alpha = \frac{\sigma_1 - \sigma_3}{2\sigma_1 - 0.5(\sigma_2 + \sigma_3)}$$

where $\mu = 0.25$. The value of the coefficient of softness for several types of stressed states is given in Table 1.

Determining Shear and Cohesive Resistance of Metals: Shear resistance, T, is determined by testing thin-walled tubes or round solid bars in torsion. In the first case, the stress distribution may be considered uniform and shear strength is calculated from the ordinary formula. In the second case, shear strength is calculated using the theory of plasticity. Other methods of determining shear strength include the direct double-shear test, and a test in which a tensile specimen is shaped so that it fails in shear, Fig. 7.

Cohesive strength, S, is determined by testing

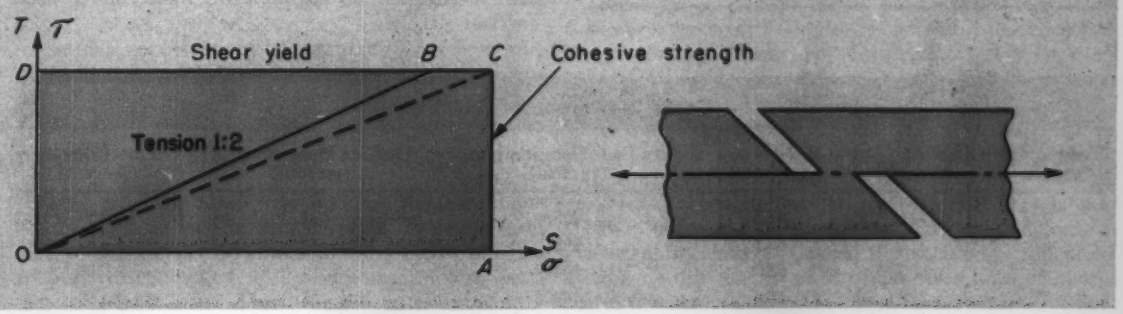


Fig. 6—Graphical representation of ductility. Degree of ductility is represented by segment *BC*.

Fig. 7—Tensile specimen shaped to fail in shear.

round notched specimens in tension. Here, the stress distribution is nonuniform, and maximum stress is calculated using the theory of elasticity. This is permissible because the metal at the bottom of the notch is practically in an elastic state due to the triaxial state of stresses. Another method is to use ordinary tensile-test specimens cooled to a very low temperature. Resistance to slip becomes greater than cohesive resistance and the specimen breaks in a cohesive manner. However, in some cases a combination of these two methods is necessary to obtain a cohesive fracture.

Evaluating Ductility by Means of a Combined Specimen: The test bar, Fig. 8, combines smooth and notched tensile specimens. It may be used for quick comparative tests of ductility for determining suitability of a metal for combined-stress service. The notched part, in a state of near-triaxial tension, fails in a cohesive manner, while the smooth part yields plastically in shear before it breaks. Since both parts are under the same load, the place of fracture indicates the relative resistance of the metal to shear or to normal stresses.

On the basis of these tests, specimens of all metals might be usefully classified into two groups: Those that break at the notch and those that fail at the smooth part. The notch effect and, therefore, the ductility may be evaluated quantitatively.

If tensile strength is greater at the notch than at the smooth part of the specimen, or $\sigma_n > \sigma_s$, then specimens can be made with tensile strengths equal at both places by decreasing root diameters of the notches. If D is the diameter of the smooth part, d the root diameter of the notch, and f the breaking load, then the stresses are: $\sigma_s = 4f/\pi D^2$ and $\sigma_n = 4f/\pi d^2$. Therefore, the coefficient of relative effect of the notch will be

$$\beta = \frac{\sigma_n - \sigma_s}{\sigma_s} = \frac{D^2 - d^2}{d^2} = \frac{D^2}{d^2} - 1$$

The greater the value of β, the more reliable the material for combined tensile-stress applications. For example, SAE 1030 steel hardened and tempered at 392 F has a value $\beta = 0.54$. For the same steel tempered at 932 F, $\beta = 0.68$.

If fracture occurs at the notch when both diameters of the specimen are equal, effect of the notch is negative. To obtain the same strength in both sections, it is necessary to increase the root diameter of the notch and β will be negative. In other words, it will indicate the possibility of a brittle fracture under combined stresses.

Evaluating Ductility for Forming Processes: At times, the ratio of shear to normal stress is difficult if not impossible to calculate. Su h is the case when large deformations are required of a forming process. Here, the criterion of ductility must be based on cross-sectional reduction since it reflects the greatest deformation of the specimen. A still better criterion of suitability is zero-gage elongation. This is the maximum possible elongation on the minimum possible length and is calculated as a function of cross-sectional reduction.

Since in the plastic range the volume of metal practically does not change,

$$A_0 L_0 = A(A_0 + \delta) = AL_0(1 + \varepsilon) \qquad (1)$$

or $A_0 = A(1 + \varepsilon)$, where A_0 and L_0 are initial area and gage length of the specimen, A is the final area, δ the total elongation, and ε the average relative elongation or ε_{av}. Relative reduction of area

Table 1—Types of Loading and Principal Stresses

Stress State	Stresses σ_1	σ_2	σ_3	Softness Coefficient α
Triaxial tension	σ	σ	σ	0
Triaxial tension, nonuniform	σ	$8\sigma/9$	$8\sigma/9$	0.1
Uniaxial tension	σ	0	0	0.5
Torsion	σ	0	$-\sigma$	0.8
Biaxial compression	0	$-\sigma$	$-\sigma$	1
Uniaxial compression	0	0	$-\sigma$	2
Triaxial compression	$-\sigma$	$-7\sigma/3$	$-7\sigma/3$	4
Triaxial compression, nonuniform	$-\sigma$	-2σ	-2σ	∞

Table 2—Criteria of Ductility

Temperature (deg F)	Elongation, ε_{av} (per cent)	Reduction, ψ (per cent)	Zero-Gage Elongation, ε_{max} (per cent)	Uniform Elongation, ε_{un} (per cent)	Gamma Criterion, γ (per cent)
212	33.9	67.2	205	14	0.59
68	37.0	66.1	195	14	0.62
32	37.7	66.0	194	14	0.63
− 22	37.8	65.4	189	16	0.58
− 76	38.6	63.0	170	17	0.56
−135	39.6	60.2	150	22	0.44
−320	24.4	30.3	43.5	22.4	0.08

is $\psi = (A_0 - A)/A_0$. Substituting A_0 into Equation 1, $\varepsilon = \psi/(1-\psi)$. Since ψ is relative reduction of area at the neck of the specimen, the value of ε is the maximum possible elongation on the minimum possible length. It is zero-gage elongation ε_{max} or ε_{conc}.

If relative reduction is measured at any point of the specimen outside of the neck, reduction and elongation are uniform, and zero-gage elongation is ε_{un}. If relative reduction is measured at the neck, zero-gage elongation is ε_{max}.

Ductility as a Function of Lateral Deformation: If a ductile metal is tested in tension to its breaking point, two kinds of cross-sectional reduction are evident: Uniformly distributed reduction along the specimen and concentrated reduction at the neck. It has also been shown that there are two kinds of elongation as a function of reduction, ε_{max} and ε_{un}.

Ductile properties of metals greatly depend upon the relative magnitude of these two kinds of deformation. Yet the ordinary value of average elongation, ε_{av}, does not reflect this relationship. In the case of high-strength steels, uniform elongation is 5 to 10 per cent of concentrated elongation. For some aluminum alloys it is 18 to 20 per cent, and for some brasses, 35 to 45 per cent. These figures indicate the importance of study of concentrated deformation which is the principal part of total deformation.

This study becomes even more important when considering the fact that uniform and concentrated deformations follow different laws under different conditions of test and service. For example, the uniform elongation of 35 per cent C-Cr-Mo steels subjected to various regimes of heat treatment, does not change significantly while concentrated elongation changes considerably. Also, experiments show that the uniform deformation of SAE 1020 steel and aluminum alloy 2014-S increase with decreasing temperature while concentrated deformation decreases. All this requires a new criterion which would reflect both types of plastic deformation.

The absolute values of the elongations will be $\Delta L_{av} = L - L_0 = \varepsilon_{av}L_0$ for total or absolute elongation, $\Delta L_{un} = \varepsilon_{un}L_0$ for uniform elongation, and $\Delta L_{conc} = \Delta L_{av} - \Delta L_{un} = (\varepsilon_{av} - \varepsilon_{un})L_0$ for concentrated or maximum elongation. Therefore, the ratio of the concentrated elongation to the average elongation is

$$\gamma = \frac{\Delta L_{conc}}{\Delta L_{av}} = \frac{\Delta L_{av} - \Delta L_{un}}{\Delta L_{av}} = \frac{\varepsilon_{av} - \varepsilon_{un}}{\varepsilon_{av}}$$

This criterion takes into account the conditions at the neck as well as outside of it. It varies from zero in the absence of a neck to unity in the absence of uniform elongation. All values are obtained from regular tensile tests. Thus, for the criterion γ, only one additional measurement is needed—the diameter outside of the neck.

Comparison of Methods for Evaluating Ductility: For comparing sensitivity of the previously described criteria of ductility, SAE 1020 annealed steel was tested at various temperatures. Results are shown in Table 2.

Note that if the temperature varies from 212 to −320 F, elongation decreases 25 per cent, reduction 56 per cent, zero-gage elongation 78 per cent, and γ 86 per cent. Thus, elongation is the poorest index of ductility. The reason is that it consists of concentrated and uniform elongation. While concentrated elongation decreases with decreasing temperature, uniform elongation increases.

Which Criterion to Use: If combined stresses are involved in a design, use of a criterion which takes into account the stress pattern is inescapable for economy and safety. But even in cases of simple loading, consideration of the relationship between shear and normal stresses is necessary, especially when the margin of safety is small or when a high-strength, low-ductility alloy is used. Here, an alloy which is suitable for torsional loading may be found dangerously brittle in tension. When selecting a material for such applications, one should be guided by the relationship $(\tau S/\sigma T) = 1 + m$ where the value of the margin of ductility m depends upon the part and conditions of service.

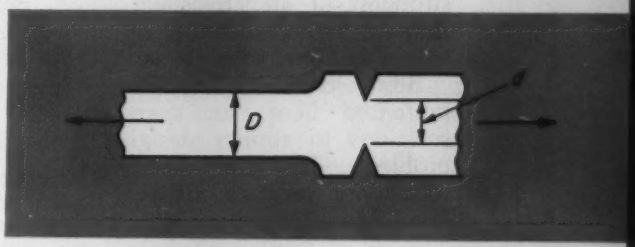


Fig. 8—Test bar combining smooth and notched tensile specimens.

Ordinary elongation data, in general, is only applicable to the design of members in tension if there is geometric similarity between the member and test specimen. For this reason, test data of bars 100 in. long and more may be very useful for applications of long rod, tubing, and wire in tension. Another extreme is the correlation between short gage length (less than 2 in.) and strains obtained in sharp bends.

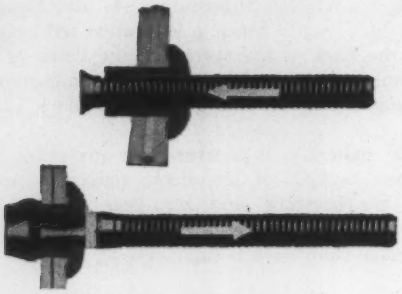
However, technological properties of metals are better evaluated by measuring the lateral deformations of specimens. Lateral deformation is independent of the length of the specimens and is more accurate and reliable than standard elongation. For such operations as forming and drawing, reduction of area is preferable to elongation, zero-gage elongation is superior to plain reduction, and the γ relationship seems to be still better.

BLIND RIVETS

Complete installation from one side of the work is a distinguishing feature of blind rivets. During installation, all types are upset by a power tool.

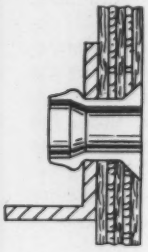
Generally, self-plugging types are stronger than pull-through types because sleeves of the former are filled during installation. Lock-spindle types are the strongest of all. In shear, they can be considered equal to conventional solid rivets.

Blind rivet applications presented here can spark solutions to similar design problems. The rivets themselves are products of the Huck Manufacturing Co.



Pull-through type . . .

has an axial hole after the pin is pulled through the sleeve and discarded. Here, the pin head collapses while it forms a "tulip" head in the sleeve. The hollow core can be used as a vent or a grommet hole.

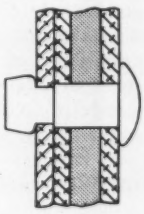


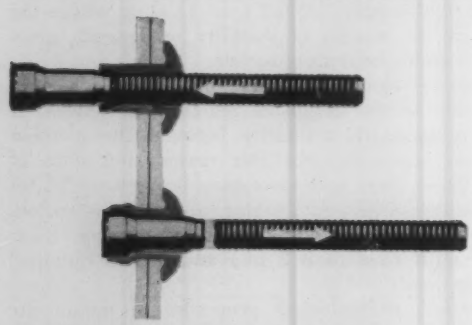
Sleeve styles . . .

of pull-through rivets include countersunk, protruding, and truss types. Countersunk design, shown, is often used for flush appearance.

Sleeves with shoulders . . .

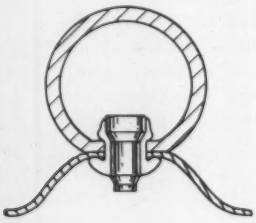
enable pull-through rivets to join panels having cores of honeycomb, or soft material, without serious deformation of cores. Because the shoulder acts as a reinforcement during installation, blind head formation is virtually independent of strength and resilience of panel materials. Shoulder types are also available in friction-lock, self-plugging rivets.





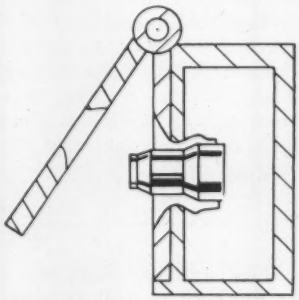
Friction-lock, self-plugging type . . .

has a solid core which is a pin shank wedged into place and broken from the pin during installation. Acting as a mandrel, the shank expands the sleeve and fills the hole completely. Nonfunctioning shank projections can be trimmed.



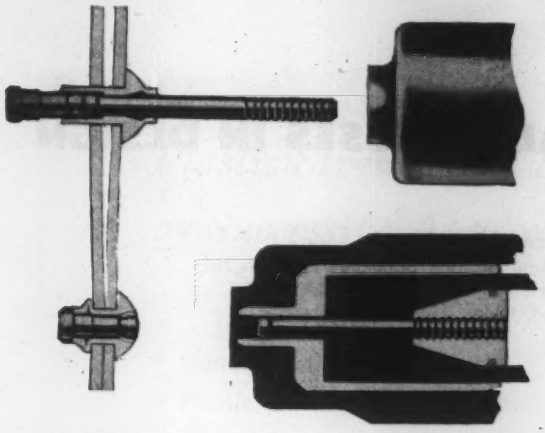
Tube attachment

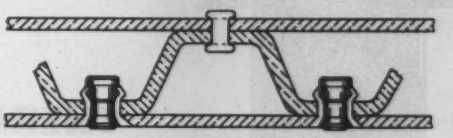
is a classic application of self-plugging blind rivets. Tubes need have only one hole.



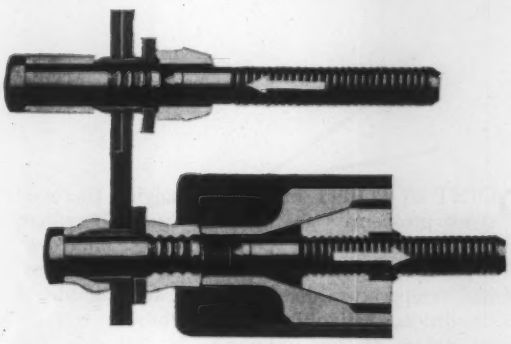
Hinge installation . . .

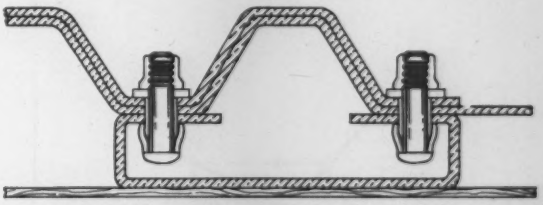
on hollow box uses countersunk-head blind rivet. Truss-head design is used where maximum bearing area is desired.



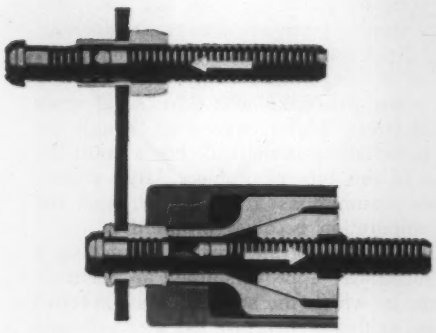


Lock-spindle, self-plugging types . . .
feature a positive mechanical lock for pin retention. Just before the pin breaks, a locking collar on the sleeve is forced into locking grooves between pin and sleeve. In this example, a "bulb" type head is formed. This head is stronger than the "tulip" type. Flush appearance results when this type, having a countersunk-sleeve style, is used to join aircraft double-skin structures.



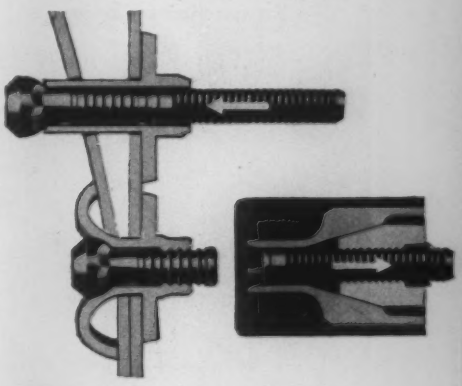


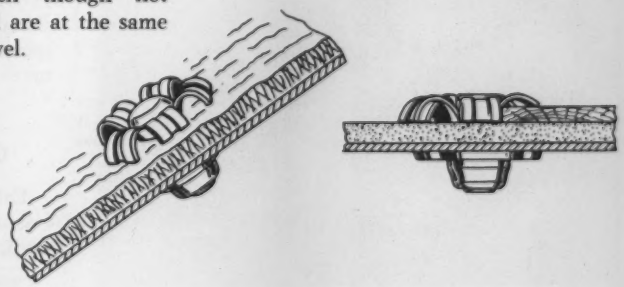
Floating, tapered sleeve . . .
enables this lock-spindle, self-plugging rivet to expand another sleeve, forming blind side head. Attachment of the rub-rail on truck-trailers is shown.



Integral collar and sleeve . . .
are used in this lock-spindle, self-plugging type. Sleeve upsets to "bulb" head during installation. Collar is swaged into locking grooves on pin.

Split-sleeve type . . .
forms a daisy-shaped head when the pin splits the sleeve during installation. Large bearing area is provided by spreading petals. The Daisy type is particularly suited for attaching insulation to sheet metal. Petals hold even though not all are at the same level.





THERMAL STRESSES IN DESIGN

S. S. MANSON
Chief, Materials and Structures Research Div.
Lewis Research Laboratory, NASA
Cleveland, Ohio

Successive-Approximation Method

Equations used to approximate values of dy/dx, when $y = 1$, $x = 0$, are:

$$y = 1 + \int_0^x y\,dx$$

For first approximation, assume $y = 1$

$$y_1 = 1 + \int_0^x (1)dx = 1 + x$$

For second approximation, assume $y = 1 + x$

$$y_2 = 1 + \int_0^x (1 + x)dx$$

$$= 1 + x + \frac{x^2}{2}$$

For third approximation, assume $y = 1 + x + \frac{x^2}{2}$

$$y_3 = 1 + \int_0^x \left(1 + x + \frac{x^2}{2}\right) dx$$

$$= 1 + x + \frac{x^2}{2} + \frac{x^3}{(3)(2)}$$

For exact solution,

$$y_\infty = 1 + x + \frac{x^2}{2} + \frac{x^3}{(3)(2)} + \frac{x^4}{(4)(3)(2)} \cdots = e^x$$

POINT-BY-POINT methods of solving thermal-stress problems[11] are ideal for situations where the logical starting point involves only one unknown. A circular plate with a radially-symmetrical temperature distribution is an example of this condition. Assigning several arbitrary but judicious values to the unknown, in this case the center stress, and expressing the stresses at all other locations in terms of the assigned value lead to the determination of the correct value when a known boundary condition is applied.

However, point-by-point solutions are not practical when the starting point involves two unknowns. For example, if the center of a long cylinder which is subjected to a temperature distribution is used as a starting point, two unknowns exist: Axial stress and tangential stress. This is true even though the temperature is radially symmetrical. For a point-by-point solution of this type of problem, large quantities of double assumptions are required, and the amount of computation becomes prohibitive.

This article describes several ways of applying a method of successive approximations to thermal-stress problems in which the starting point involves two unknowns, or the temperature has a two-dimensional distribution. Although the descriptions refer specifically to solutions by deformation theory, the methods are equally valid for incremental approaches.

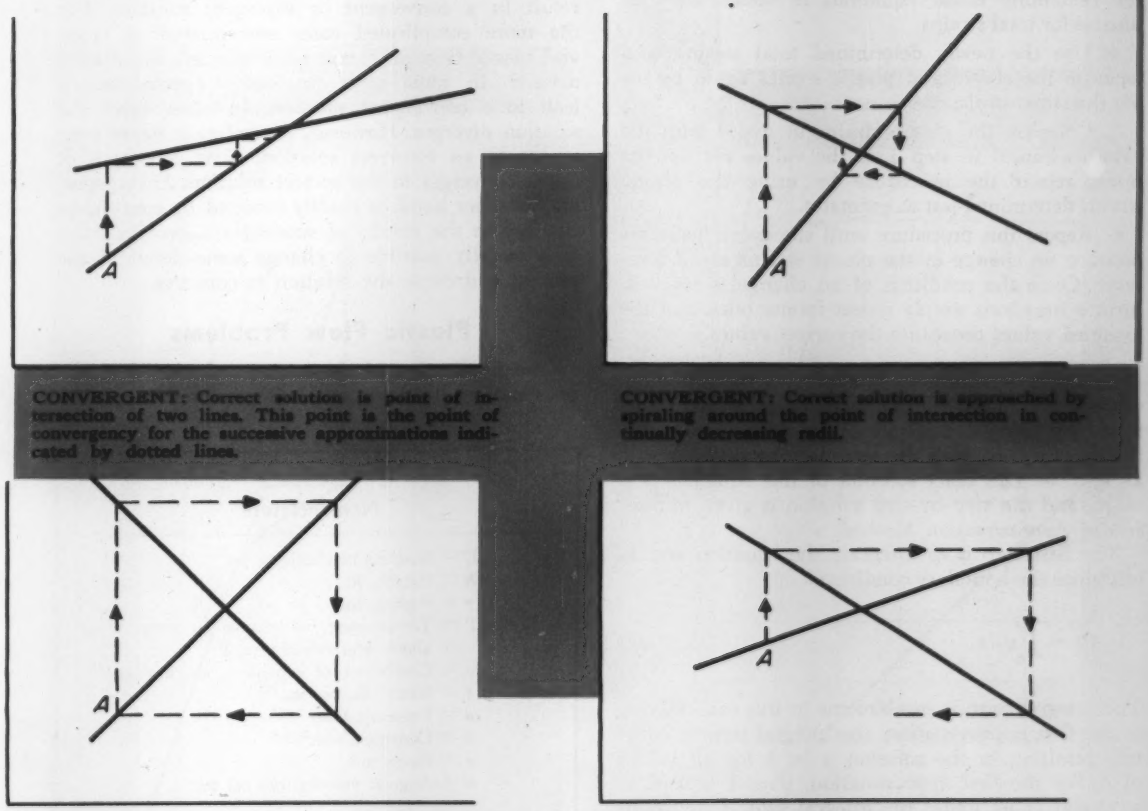
General Procedure for Solution

Difficulties in solving plastic-flow problems arise because of the nonlinear stress-strain relation. The nonlinear terms appear in differential equations

[11]References are tabulated at end of article.

Part 12 — Plastic Stresses and Strains by Successive Approximations

- **General Solution**
- **Plastic Flow Problems**



CONVERGENT: Correct solution is point of intersection of two lines. This point is the point of convergency for the successive approximations indicated by dotted lines.

CONVERGENT: Correct solution is approached by spiraling around the point of intersection in continually decreasing radii.

REPETITIVE: Lines for successive approximations do not approach correct solution. Successive solutions repeat themselves, but never converge.

DIVERGENT: Successive solutions get farther and farther away from correct solution which is represented by point of line intersection.

Fig. 71—Convergence possibilities for successive-approximation solution of two simultaneous thermal-stress equations. Starting point in all cases is *A*.

which become troublesome if solution is attempted by rigorous analytical techniques. However, if the nonlinear terms are considered to be known quantities, the remaining terms comprise a system of linear differential equations which are more readily solved.

By considering nonlinear terms as known quantities, the following procedure can be used for solution:

1. Neglect the nonlinear terms induced by plastic flow and solve the equations. The result essentially constitutes an elastic solution, which is usually obtained as a starting point.

2. Separate the elastic portion of the equation from the plastic portion by using the stress-strain curves and the strains, or occasionally the stresses, determined from the elastic solutions.

3. Assume that the plastic strains determined in step 2 are correct. Substitute the numerical quantities for the plastic strains into the original equations wherever the nonlinear terms appear. This converts all nonlinear terms to numerical quantities. Re-solve the remaining linear equations to obtain new estimates for total strains.

4. Use the newly determined total strains, and separate the elastic and plastic strains again by using the stress-strain curves.

5. Compare the plastic strains in step 4 with the values assumed in step 3. If the values are not the same, repeat the procedure by using the plastic strains determined last as estimates.

6. Repeat this procedure until successive iterations produce no change in the plastic strains at all locations. Once the condition of no change is reached, further iterations simply repeat former ones, and the assumed values constitute the correct values.

Example of Solution: The process for obtaining successively improved approximations is best illustrated by using the simple linear differential equation $y = dy/dx$, with the boundary condition $y = 1$ at $x = 0$. The exact solution of this equation is $y = e^x$, and the step-by-step solution is given in *Successive Approximation Method.*

The first step is to integrate the equation and to introduce the boundary condition

$$y = 1 + \int_0^x y\,dx \qquad (88)$$

The integral term is troublesome in this case. Hence, in the first approximation, the integral term is omitted, resulting in the solution $y = 1$ for all values of x. For the first approximation, $y = 1$ is used as a known value under the integral sign. This results in a value for y which is used as the assumed value for the second approximation. Each successive approximation adds one term to the power-series which, in the limit, is the exact expansion of e^x. The correct solution is obtained if a sufficient number of approximations are performed. The number of approximations necessary for the desired accuracy depends upon the range in x values required.

Convergence: Correctness of the successive approximation approach and of the final solution depends upon whether or not the process leads to a nonchanging solution. The concept of convergence is the criterion used to determine the correctness. This concept is illustrated in Fig. 71 for the extremely simple case of two simultaneous linear algebraic equations.

The procedure used here for illustration only consists of arbitrarily selecting a value for y, using one of the linear equations to determine x for this value of y, using this value of x in conjunction with the second equation to determine a new value of y, and substituting the new value of y into the first equation to get a new value of x. The process is repeated, alternating between the two equations, to obtain new values for x and y respectively. While this procedure is relatively simple for the two illustrative equations, an analogous approach is helpful when a very large number of simultaneous equations are to be solved.

For a simple problem of the type illustrated, rules can be set down to determine in advance whether a given procedure of successive approximations will result in a convergent or divergent solution. For the more complicated cases encountered in creep and plastic flow problems, such rules are not readily devised. In some cases, successive approximations lead to a convergent solution. In other cases the solution diverges. However, the solution never converges to an incorrect solution. If it converges at all, it converges to the correct solution. Divergence, on the other hand, is readily detected by continuous changes in the results of successive approximations. It is usually possible to change some detail of the process and cause the solution to converge.

Plastic Flow Problems

One application of the concept of successive approximations has been used in the solution of plastic-

Nomenclature

E = Modulus of elasticity, psi
h = Height, in.
r = Radius, in.
T = Temperature, or change in temperature above reference of zero, F
α = Coefficient of expansion, in./in./deg F
ε = Strain, in. per in.
μ = Poisson's ratio
ρ = Density, lb-sec^2/ft^4
σ = Stress, psi
ω = Angular velocity, rad per sec

Subscripts:
e = Equivalent
p = Plastic
r = Radial
t = Total
z = Axial
θ = Tangential

flow problems for gas-turbine discs.[12] Details of the approach are slightly different from those previously outlined for the general procedure. Use was made of a combination of stresses and strains as determined from prior calculations in order to effect an improved estimate. The procedure is shown in Fig. 72.

First step in the process is to compute the elastic stress distribution, ignoring the possibility of plastic flow. The equivalent stresses are then determined from Equation 74. If, at any station, this equivalent stress exceeds the proportional elastic limit of the material at the station temperature, plastic flow takes place, and it becomes necessary to use a trial-and-error procedure to adjust the stresses.

For example, assume the equivalent uniaxial stress at a given station lies at point *A* on the extension of the modulus line, Fig. 72. Because point *A* lies above the proportional elastic limit, point *B*, plastic flow occurs. Hence, the stress and the strain must be adjusted to fail on the curved stress-strain relation that is characteristic for the material. As a starting point, the total strain in the true stress-strain condition is assumed equal to the strain at *A*. The stress-strain condition at the given station then lies on the constant-strain line through *B*. This condition is satisfied by point *C*, and the total plastic strain is given by line *CD*. Values of the radial and tangential plastic strains may be obtained by using this value of total plastic strain together with the values of radial, tangential, and equivalent stresses obtained from elastic calculations and the application of Equation 76.

New values of radial, tangential, and equivalent stresses can be computed utilizing the equilibrium and compatibility relations. In applying the com-

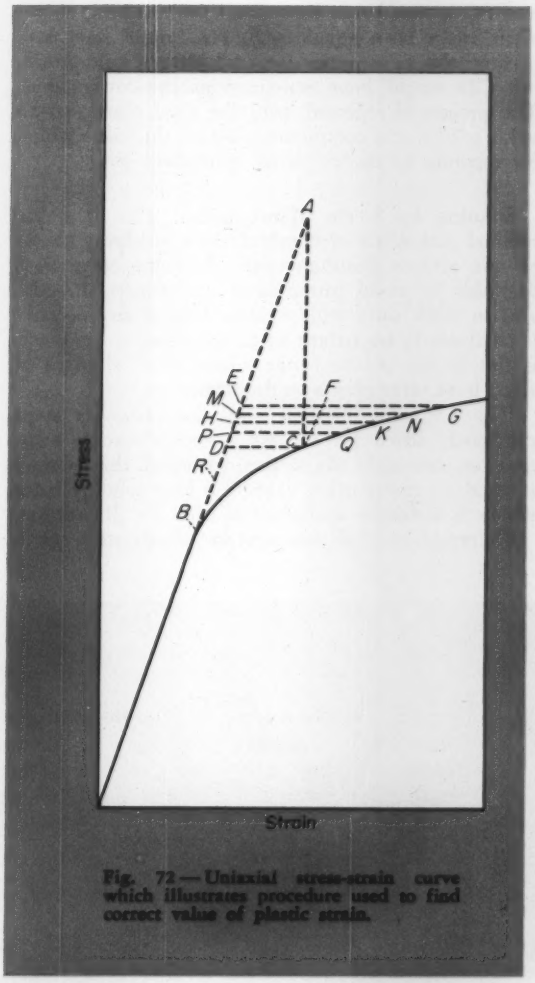


Fig. 72 — Uniaxial stress-strain curve which illustrates procedure used to find correct value of plastic strain.

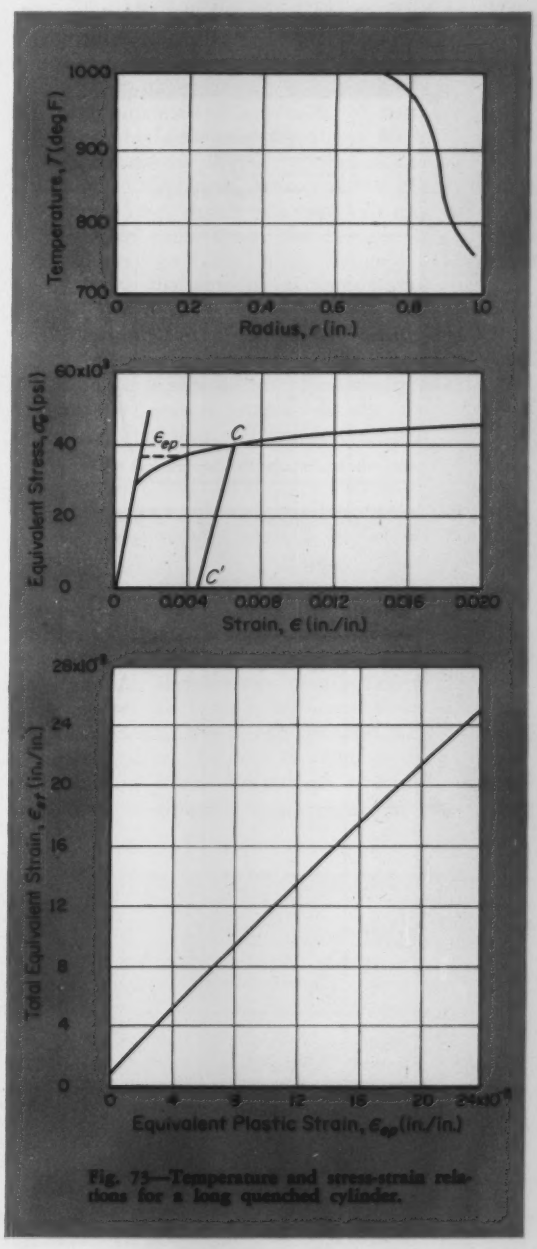


Fig. 73—Temperature and stress-strain relations for a long quenched cylinder.

patibility equation the total strain is taken as the elastic strain due to the unknown stresses plus the plastic strain as determined from the first iteration. The new value of equivalent stress, point *E*, is greater than that at point *D*. Although the stresses corresponding to the equivalent stress at point *E* and the strain *CD* meet the conditions of equilibrium and compatibility, they locate the stress-strain point *F*, which is not on the stress-strain curve. Hence, the physical conditions imposed by the material are as yet unsatisfied.

Since any total plastic strain value less than *CD* would give an equivalent stress value greater than that at *E*, *CD* is a lower limit of the total plastic strain. Similarly, since equivalent stress calculated using a total plastic strain equal to *CD* is too great, the increment of strain *EG* corresponding to the equivalent stress is an upper limit of the total plastic strain. Furthermore, since the true value of total plastic strain lies between *CD* and *EG*, their numerical average, shown as *HK*, is assumed to be good approximation. New values of radial, tangential, and equivalent stresses can be computed by using *HK* for equivalent strain, stress at *E* for equivalent stress, and the radial and tangential stress values.

Assume that this new value of equivalent stress falls on the point *M*. Because the stress at *M* is higher than the stress at *H*, the increment *HK* is too small for a value of total plastic strain and is therefore established as a new lower limit of total plastic strain. Furthermore, since *M* is less than *E*, the corresponding increment *MN* is a new upper limit for total plastic strain, and the process could be repeated again with the numerical average of *MN* and *HK*.

Similarly, if the calculation using a total plastic strain equal to *HK* had resulted in an equivalent stress at *P*, *HK* would constitute a new upper limit and *PQ* a new lower limit. Had the resulting equivalent stress been equal to *R*, *HK* would have still become the new upper limit of total plastic strain, but *CD* would have remained as the lower limit. The process is repeated until the total plastic strain value used in the computation equals the value which corresponds to the resulting equivalent stress.

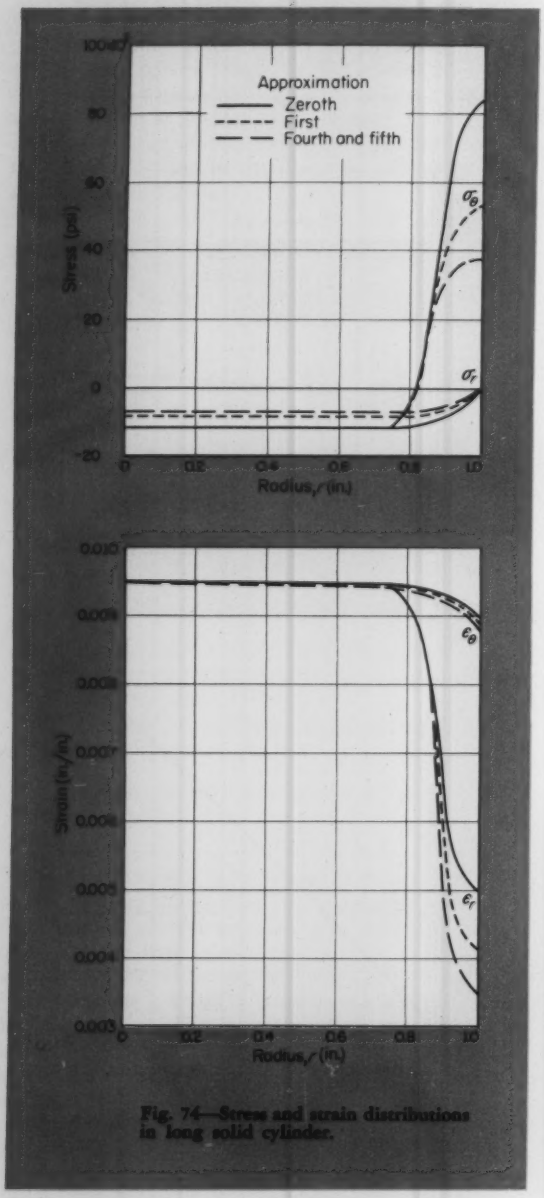


Fig. 74—Stress and strain distributions in long solid cylinder.

Solution by Strain Manipulation: The foregoing method makes use of manipulations involving stresses and strains simultaneously. In some cases it is desirable to avoid introducing the stresses directly, and to work only with strains. Use of strains only is particularly important when the stress-strain curve is flat in the plastic range where small changes in stress have large effects on the strain.

The following method uses the same six steps previously listed for successive-approximation solution but uses only the strains. Although this method is valid for many other cases,[13] a long solid cylinder which is suddenly quenched is used for illustration.

Determination of temperature distribution as a

Station Number n	Cylinder Radius r (in.)	Thermal Strain αT (in./in.)	Radial Plastic Strain $\varepsilon_{r,p}$ (in./in.) (prev. approx.)
1	0	9.50×10^{-3}	0
2	0.75	9.50	0
3	0.80	9.20	0
4	0.85	8.81	0
5	0.90	7.68	0
6	0.95	7.06	0
7	1.000	6.62	0

function of time is a problem in heat conduction and is not considered here. It is assumed that the temperature at any instant is known, and that it is necessary to determine the stress and strain distribution only. Fig. 73 shows the temperature distribution in the cylinder. A stress-strain relation for the material is assumed which will hold for all temperatures. The method of treating cases in which the stress-strain relation varies with temperature will be discussed later.

Expressions for total strains in terms of plastic strains are developed from the equilibrium, compatibility, and stress-strain relations. Because the problem is one of circular symmetry, the equilibrium and compatibility equations used are Equations 22 and 24[6] with $h = 1$ and $\omega = 0$. In addition, use is made of the plane deformation condition; therefore, axial displacement only occurs in all planes. Hence, ε_z = constant. Finally, the cylinder is assumed unrestrained at the ends. Therefore, the net axial force across a plane $\int \sigma_z r dr$ is zero. These conditions lead to the following equations for the strains: (see Nomenclature)

$$\varepsilon_\theta = \frac{1+\mu}{r^2(1-\mu)} \int_0^r \alpha T r dr + \frac{1-2\mu}{2r^2(1-\mu)} \int_0^r (\varepsilon_{r,p} + \varepsilon_{\theta,p}) r dr + \frac{1-2\mu}{2(1-\mu)} \int_0^r \frac{\varepsilon_{r,p} - \varepsilon_{\theta,p}}{r} dr + C_1 \quad (89)$$

$$\varepsilon_r = -\varepsilon_\theta + \frac{1+\mu}{1-\mu} \alpha T + \frac{1-2\mu}{1-\mu} \varepsilon_{r,p} + \frac{1-2\mu}{1-\mu} \int_0^r \frac{\varepsilon_{r,p} - \varepsilon_{\theta,p}}{r} dr + 2C_1 \quad (90)$$

$$\varepsilon_z = \frac{2}{R^2} \left[\int_0^R \alpha T r dr - \int_0^R (\varepsilon_{r,p} + \varepsilon_{\theta,p}) r dr \right] \quad (91)$$

where

$$C_1 = \frac{1-3\mu}{R^2(1-\mu)} \int_0^R \alpha T r dr - \frac{1-2\mu}{2(1-\mu)} \int_0^R \frac{\varepsilon_{r,p} - \varepsilon_{\theta,p}}{r} dr + \frac{1}{2R^2(1-\mu)} \int_0^R (\varepsilon_{r,p} + \varepsilon_{\theta,p}) r dr \quad (92)$$

Equations 89 through 91 are solved by successive approximations as previously outlined. The zeroth approximation of the total strains is obtained by assuming that $\varepsilon_{r,p}$ and $\varepsilon_{\theta,p}$ are zero. The total equivalent strain is then computed from Equation 80,[11] the equivalent plastic strain is read from Fig. 68,[11] and first approximations to $\varepsilon_{r,p}$ and $\varepsilon_{\theta,p}$ are substituted into Equations 89 through 91 and new approximations are obtained for ε_r, ε_θ, and ε_z. The process is then repeated as many times as necessary to obtain the desired degree of convergence. The stresses are computed at any time from the general stress-strain relations, Equation 79.[11] Computations are shown in Table 1 for the first iteration. Results for various other iterations, Fig. 74, show that relatively few iterations are required to obtain convergence.

Rapidity of Convergence: The problem of convergence is of considerable importance in a successive-approximation approach of this type. For solutions obtained from Equations 89 through 91, it can be shown that conditions for convergence are satisfied.[14] Hence, correct solution results if a sufficiently large number of iterations are performed. However, in some cases, the number of iterations required may be fairly large. When it is desirable to minimize the amount of computation required, at least two devices can be used: 1. Start with an initial assumption of stress or strain distribution that is as close as possible to the correct solution. 2. Introduce a scheme for re-estimating the correct solution at several stages during the iteration process, rather than relying solely upon the prior iteration.

Assumption that the elastic-strain distribution was correct has lead to good results in cases which involved only thermal loading.[13] Final strain distributions in these cases differed little from the initially assumed strain distributions.

When external loading is applied, or when highly localized yielding takes place while the remainder of the body remains elastic, the assumption that the elastic-strain distribution is preserved may not be the best initial assumption. Idealized and simplified analyses, experimental measurements, or experience can be used to estimate the best possible starting point. Very often it is advantageous to make a preliminary computation in which only

Table 1—Solution for Strains in Long Solid Cylinder

Plastic Shear Strain $\varepsilon_{s,p}$(in./in.) (prev. approx.)	Radial Strain ε_r(in./in.) (Equation 90)	Tangential Strain ε_θ(in./in.) (Equation 89)	Longitudinal Strain ε_z(in./in.) (Equation 91)	Total Equivalent Strain $\varepsilon_{e,t}$(in./in.) (Equation 80[11])	Equivalent Plastic Strain $\varepsilon_{e,p}$(in./in.) (Fig. 68[11])	Radial Plastic Strain $\varepsilon_{r,p}$(in./in.) (Equation 82[11])	Tangential Strain $\varepsilon_{t,p}$(in./in.) (Equation 82[11])
0	9.457×10^{-3}	9.457×10^{-3}	8.912×10^{-3}	0.368×10^{-3}	0×10^{-3}	0×10^{-3}	0×10^{-3}
0	9.462	9.462	0	.263	0	0	0
0	9.465	9.439	0	.310	0	0	0
0	5.240	9.302	0	.668	0	0	0
0	6.236	9.299	0	1.926	0.91	−0.907	0.545
0	5.274	9.109	0	2.494	1.40	−1.397	0.754
0	5.045	8.911	0	2.978	1.43	−1.477	0.738

a few stations in the plastic range are used. Thus, convergence is rapid although the accuracy of the solution is restricted. The resulting solution may, however, be a better starting point for a more refined solution which involves more stations.

Also, the rate at which the strain at a given point changes from one iteration to the next can be observed and the results can be extrapolated to a zero rate. For example, it is possible to perform three or four iterations, plot at each station the strain difference per iteration against the assumed strain, and extrapolate the resulting plot to a strain which will cause zero difference per iteration. The strain distribution obtained in this manner can then be used as a new starting point. Several additional iterations are then performed and the process repeated.

Solution by Other Methods: Thus far, the equations used have been directly integrable if the plastic strain terms were regarded as known quantities. In some cases, closed form integration is not possible. Methods which involve finite differences, collocations, or other approximation techniques must occasionally be used to solve the differential equations once the plastic strains have been estimated from a prior iteration. Therefore, many of the techniques described under elastic solutions become applicable if the plastic-strain terms are included in the stress-strain relations.

The next article in this series will describe how thermally induced plastic stresses and strains can be determined by using an incremental approach.

REFERENCES

This article is the twelfth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" .....June 12, 1958
2. "Quantitative Techniques for Brittle Materials" ..June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" ... . August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ....August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" .....January 22, 1959
7. "Exact and Approximate Solutions" .....February 5, 1959
8. "Elastic Stresses by Energy Methods" .....February 19, 1959
9. "Elastic Stress Solutions" .....March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ....March 19, 1959
11. "Stresses Under Plastic Flow and Creep" .....July 9, 1959

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12. M. B. Millenson and S. S. Manson—"Determination of Stresses in Gas Turbine Disks Subjected to Plastic Flow and Creep." *NACA Report No.* 906, 1948.
13. A. Mendelson and S. S. Manson—"Practical Solution of Plastic Deformation Problems in the Elastic-Plastic Range." *NACA TN* 4088, Sept. 1957.
14. E. L. Ince—*Ordinary Differential Equations.* Dover Publications Inc., New York, N. Y., 1944.

Tips and Techniques

Finding Highest Common Factors

In gear train calculations, it is often necessary to find the highest common factor between two numbers A and B, where $A \geqq B$. The procedure is simplified by dividing A by B and comparing B and the remainder, R. The highest common factor between A and B will also be the highest common factor between B and R. If the factor is not apparent, B is divided by R and the second remainder R' is compared with R.

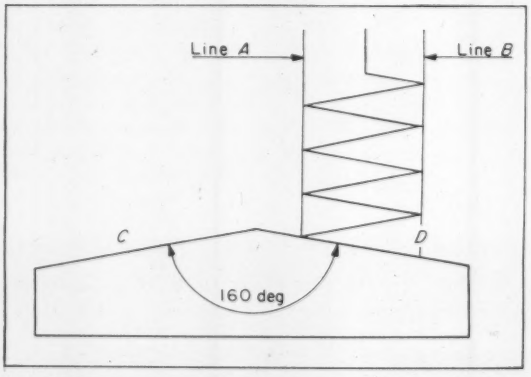
EXAMPLE: Find the highest common factor of 81 and 117. Divide 117 by 81 to obtain a remainder of 36. Since the highest common factor between 36 and 81 is not apparent, divide 81 by 36 to obtain a second remainder of 9. By inspection 9 is the highest common factor between 9 and 36. Hence 9 is the highest common factor between 81 and 117. —JESSE ROTH, *New York, N. Y.*

Spherical Areas

Corrections are necessary to "Finding Equivalent Spherical Areas," Page 165, in the May 14 issue of MACHINE DESIGN. The last paragraph should read, "Any number of segments can be obtained by this method as long as $r \geqq R/2$ and $a \leqq R$. For this construction the chord length for the spherical segment equals $2[a(2r - a)]^{1/2}$."

Spring Template

A template of plastic as shown can be used efficiently for making spring representations on drawings. Two parallel lines, A and B, are drawn to represent the outside spring diameter. Side C of



the template is used to draw a line from line A to line B. Side D is used to draw a line from line B back to line A as shown. The process is repeated to give the required spring height. — J. H. G. CLAESSENS, *Settard, Holland.*

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Graphs simplify

deflection calculations for

Curved-End Cantilevers

ALEXANDER BLAKE
Section Head
Research Center
Associated Spring Corp.
Bristol, Conn.

CANTILEVER structures with straight and curved portions, Fig. 1, find application in a number of common design elements, such as springs, retaining brackets, and other machine components. Determination of bending stress S for such structures is quite straightforward when beam dimensions and end load P are known. Maximum bending moment M is simply the load times the distance between the point of application and the fixed support. Stress can be calculated from the conventional beam expression, $S = Mc/I = M/Z$ where Z is the section modulus.

For deflection calculations, however, the usual formula for a straight cantilever beam, $Y = PL^3/3EI$, does not apply directly to these structures because of the difficulty in determining the value of effective length L that should be used.

A method frequently used today for determining deflection of curved-end cantilevers is that of Castigliano. It is based on the mechanical energy which is stored in an elastically stressed system and can be recovered upon the removal of external loads.

In general, the method states that for any combination of external loads, deflection of an elastic structure at the point of application of any load and in the direction of that load is equal to the partial derivative of the total work done by the external loading with respect to the given load. This energy method offers the advantage that it does not involve evaluation of integration constants which always appear in the usual solution of the second-order differential equation of the elastic curve of a beam.

Fundamental design equations and charts for rapid calculation of vertical and horizontal deflections in curved-end cantilevers under varying load conditions are presented in this article. Derivations are based on the Castigliano method of analysis.

To find the vertical and horizontal deflection of a curved-end cantilever beam, Fig. 1, the beam is first divided into convenient portions *AB* and *BC*.

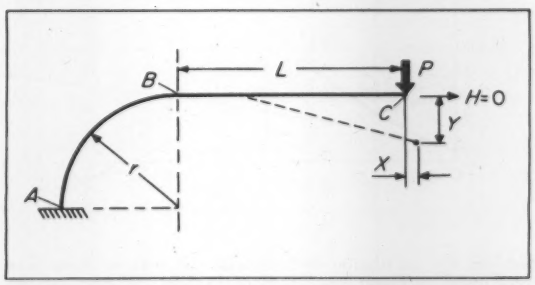


Fig. 1—Load and deflection relationships for curved-end cantilever consisting of a quarter-circle bend *AB* and straight portion *BC*.

Nomenclature

E = Modulus of elasticity, psi
H = Fictitious horizontal load, lb
I = Moment of inertia of beam cross section, in.^{4}
K = Ratio of straight length to radius of curvature $= L/r$
L = Length of straight portion of beam, in.
M = Bending moment, lb-in.
P = Concentrated vertical load, lb
r = Radius of curvature, in.
S = Bending stress, psi
U = Elastic strain energy in bending, in.-lb
X = Horizontal deflection, in.
Y = Vertical deflection, in.

Bending moment equations are then developed for each portion. The effect of shearing forces on deflection is negligible in relation to that of flexing. This condition is generally valid for structural members in which cross-sectional dimensions are small compared with length or radius of curvature.

Vertical Deflection: Total strain energy U of the structure in Fig. 1 may be expressed in terms of bending moment M and flexural rigidity EI (see Nomenclature),

$$U = \frac{1}{2EI}\int M^2 dx$$

According to the principle of Castigliano, total deflection Y under load is

$$Y = \frac{\partial U}{\partial P}$$

The integration should be extended separately for the straight and curved portions of the beam. Thus, for the straight portion,

$$Y_1 = \frac{PL^3}{3EI}$$

Similarly, for the curved portion,

$$Y_2 = \frac{Pr}{EI}(1.5708\,L^2 + 2Lr + 0.7854\,r^2)$$

Total deflection Y for the curved-end cantilever is

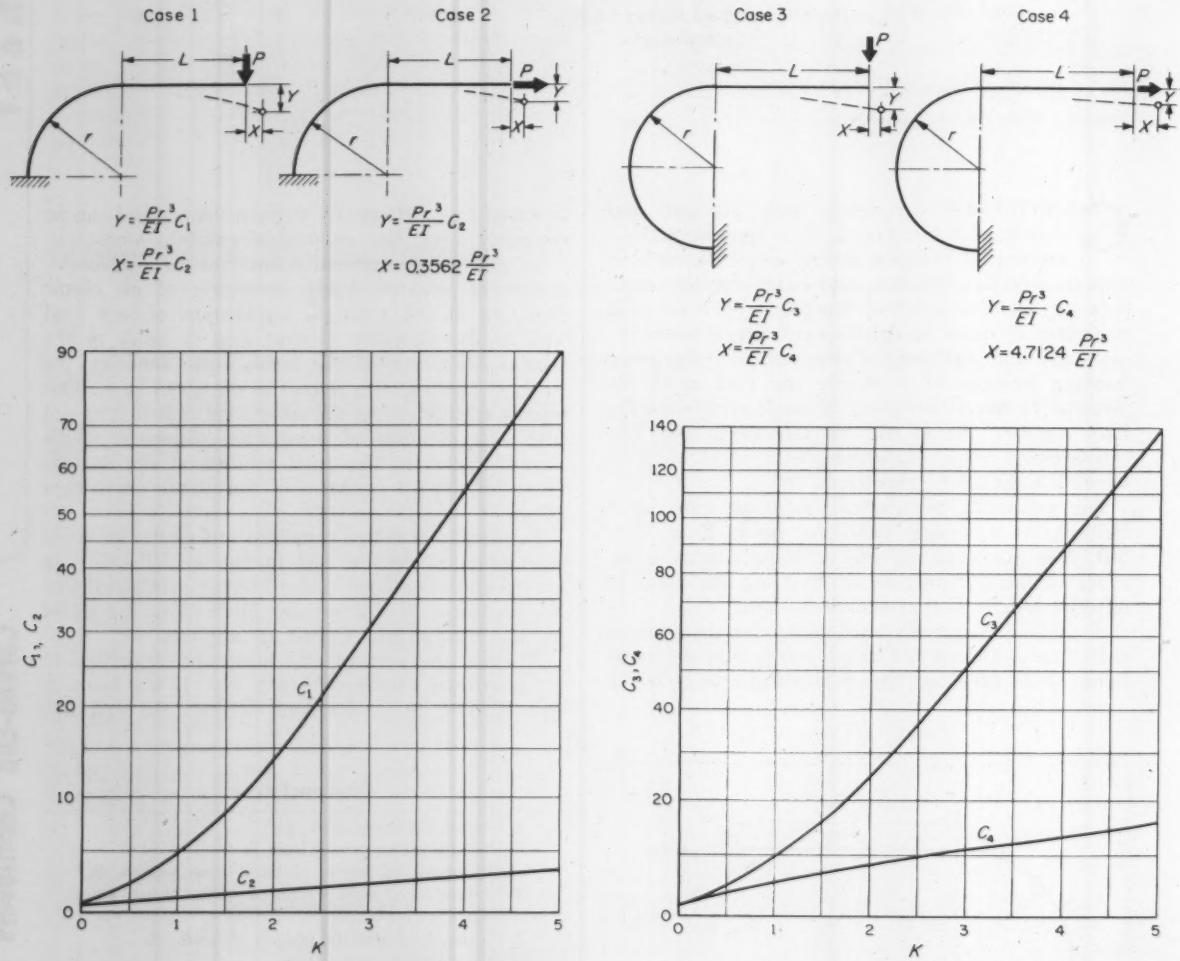


Fig. 2—Charts and equations for calculation of horizontal and vertical deflections in curved-end cantilevers under different conditions of loading. Values for calculation factor C for vertical and horizontal deflections are given by the corresponding graphs for each condition of loading. Note that when C_4 becomes negative, vertical deflection in Case 7 and horizontal deflection in Case 8 must be opposite to those shown in the sketches for Cases 7 and 8.

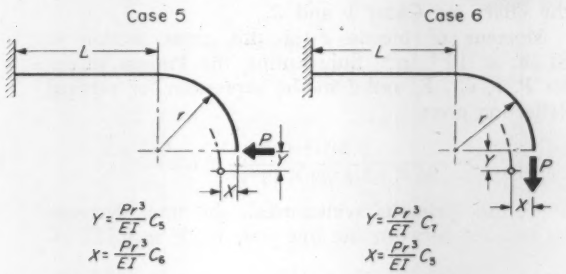
the sum of the deflections for both portions of the beam,

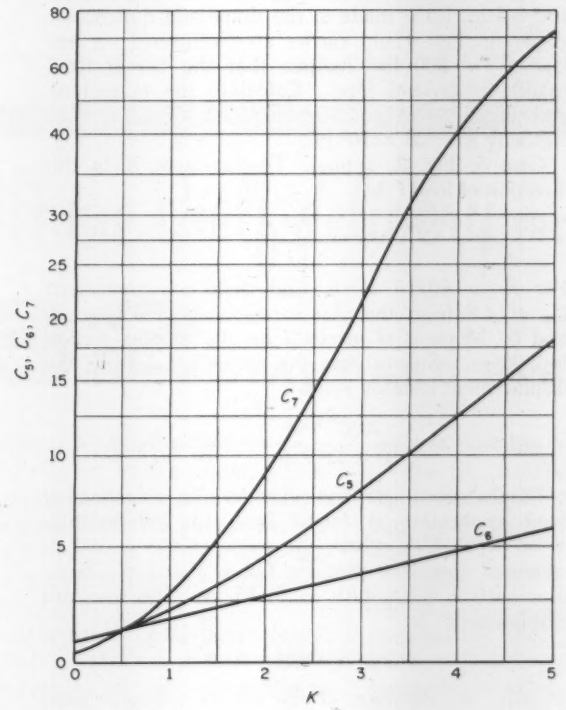
$$Y = \frac{Pr^3}{EI}(0.3333\,K^3 + 1.5708\,K^2 + 2K + 0.7854) \qquad (1)$$

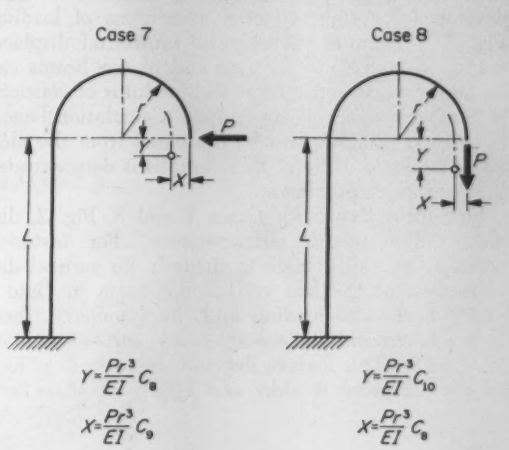
where $K = L/r$.

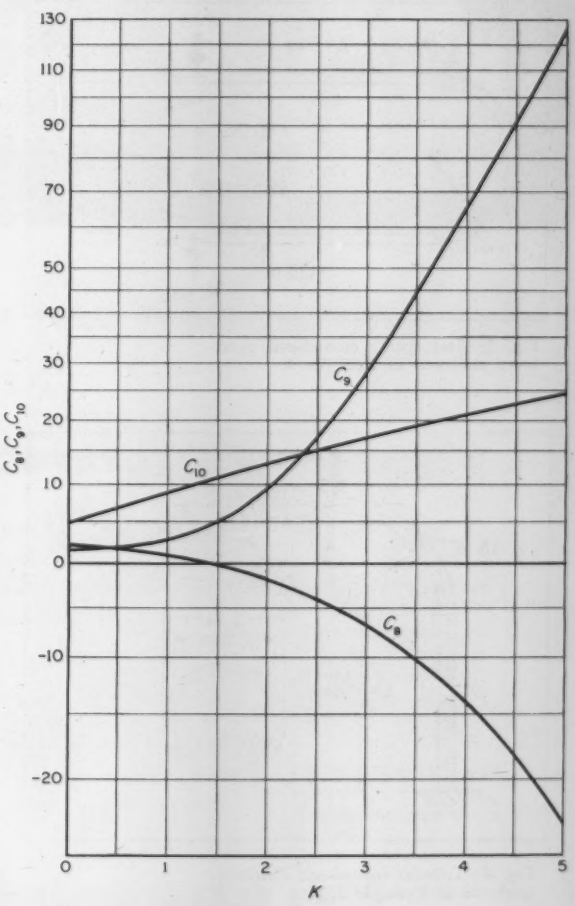
Horizontal Deflection: To calculate deflection in the direction perpendicular to that at which a given load P is acting, a fictitious and infinitely small load H is assumed to act parallel to length L, Fig. 1. Total work done on the structure is expressed in terms of the two loads. The partial derivative of the work done with respect to the fictitious load H can then be evaluated.

Next step is to determine the bending moment equation for the curved portion, AB, of the beam. The straight beam portion, BC, is excluded from the analysis since there is no bending in this portion due to load H and the effect of the direct stress is negligible. Load H is then made equal to









zero to obtain the expression for horizontal deflection,

$$X = \frac{Pr^3}{EI}(0.5 + 0.5708K) \qquad (2)$$

Design Calculations: Based on the same approach used for Equations 1 and 2, expressions have been developed for eight common conditions of loading, Fig. 2. Maximum vertical and horizontal displacements, Y and X, of the free end of the beams can be found when end load P and modulus of elasticity of the beam material are known. Calculation factors C in each equation can be evaluated from the plots given in Fig. 2. Use of these graphs is demonstrated in the example problems.

Structures shown for Cases 7 and 8, Fig. 2, display rather special characteristics. For instance, when $K = 1.414$, there is virtually no vertical displacement of the free end of the beam in Case 7 under horizontal loading and, by symmetry, there is no horizontal deflection under vertical loading in Case 8. This feature depends on ratio K as long as the structure is thin and effects of shear and direct forces on deflection can be neglected. Such structures may be used as springs or retaining members in special applications.

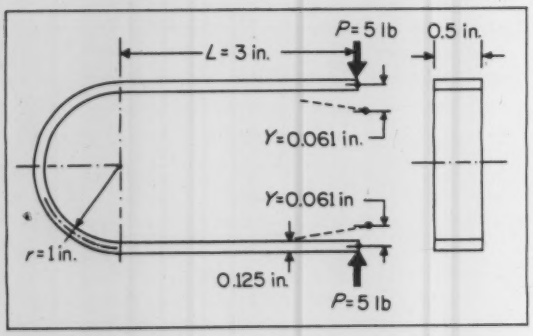


Fig. 3—Flat spring curved-end cantilever analyzed in Example 1.

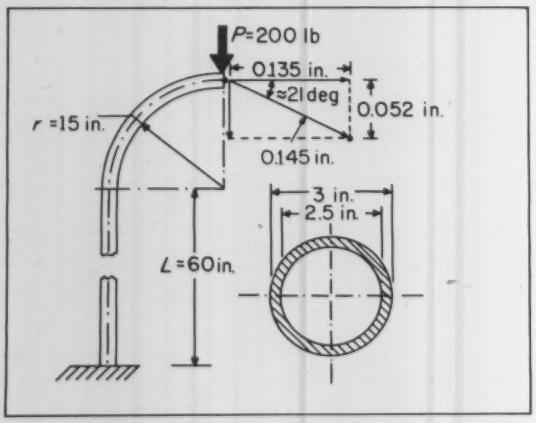


Fig. 4—Tubular curved-end cantilever analyzed in Example 2.

Example 1: A flat spring employed in a mechanical device is made of steel and precurved to the form shown in Fig. 3. If the modulus of elasticity $E = 30 \times 10^6$ psi, calculate the decrease in distance between the free ends under concentrated end load $P = 5$ lb. The ratio of straight length L to the radius of curvature r is $K = 3$. The remaining spring dimensions are shown in Fig. 3.

Case 1, Fig. 2, applies here. The expression for vertical deflection of one half of the beam is

$$Y = \frac{Pr^3}{EI}C_1$$

For $K = 3$, calculation factor $C_1 = 30$ is given by the chart for Cases 1 and 2.

Moment of inertia I of this cross section is 81.38×10^{-6} in.^{4} Substituting the known values for P, r, C_1, E, and I in the expression for vertical deflection gives

$$Y = \frac{5(30)1^3}{30 \times 10^6(81.38 \times 10^{-6})} = 0.061 \text{ in.}$$

Since the spring is symmetrical, the total decrease in distance between the free ends is $2Y = 0.122$ in.

Example 2: A steel tubular bar with a 3-in. OD and 2.5-in. ID is made to the shape and dimensions shown in Fig. 4 and carries a concentrated vertical load $P = 200$ lb. Assume that the bar is fixed rigidly at ground level. Calculate the magnitude and direction of end displacement if modulus of elasticity $E = 28 \times 10^6$ psi.

Case 5, Fig. 2, applies. Displacement X in the direction of load P is

$$X = \frac{Pr^3}{EI}C_6$$

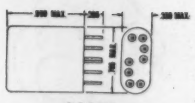
For $K = 60/15 = 4$, find deflection coefficient $C_6 = 4.8$ from the plot corresponding to Cases 5 and 6. Moment of inertia I for the tubular section is 2.06 in.^{4} Substituting the numerical data in the displacement formula yields

$$X = \frac{200(15^3)4.8}{30 \times 10^6(2.06)} = 0.052 \text{ in.}$$

Displacement perpendicular to the direction of load application is found from the relationship, $Y = X(C_5/C_6)$, where the value of $C_5 = 12.5$ is obtained from the plot for Cases 5 and 6. Thus, $Y = 0.052\ (12.5/4.8) = 0.135$ in. The resultant displacement is

$$\sqrt{0.135^2 + 0.052^2} = 0.145 \text{ in.}$$

Finally, the direction of the resultant displacement is given by the tangent of the angle of inclination, $X/Y = 0.052/0.135 = 0.3860$. The angle corresponding to this tangent value is approximately 21 deg.



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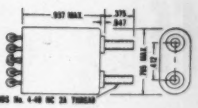

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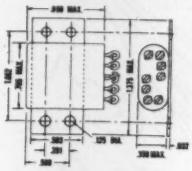

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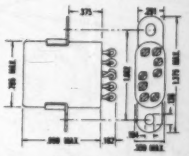

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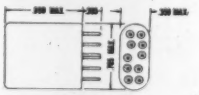

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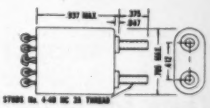

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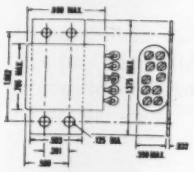

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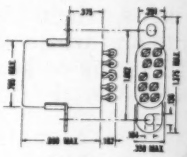

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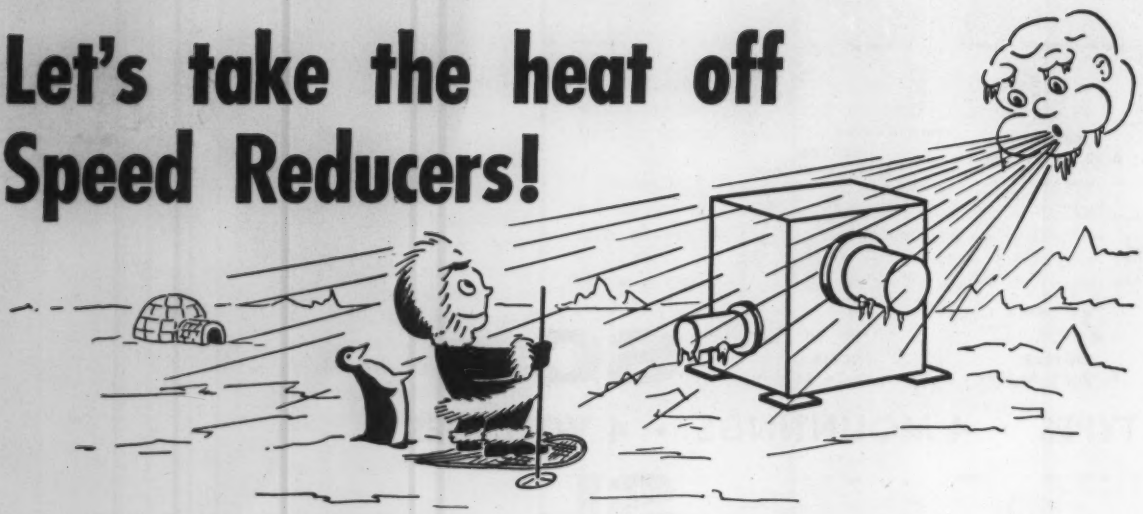

A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

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Circle 483 on Page 19

How to select silicone rubber for

High-Temperature Static Seals

H. E. TODD and **J. F. MIAZGA**
Project Chemist Senior Chemist
Pratt & Whitney Aircraft Div.
United Aircraft Corp.
East Hartford, Conn.

RUBBER is one of the materials which cannot be adequately specified for procurement purposes on the basis of composition. Specifications are generally based on performance characteristics and define these materials in terms of physical-property capabilities. In the case of specifications for elastomers, property requirements are frequently expressed in terms of conventional tests which are simple, easy to perform, of short duration, or for which test equipment is readily available.

Many specifications attempt to control a material for a variety of shapes, forms, and applications with a single set of conventional property requirements completely unrelated to peculiar functional requirements demanded of the material in specialized applications. The result is that these specifications fail to define accurately specific properties necessary for the successful operation of such parts as seals. This has been the situation for existing silicone-rubber specifications.

A second complicating factor is temperature. The same temperature requirements which led to the adoption of silicone rubber for seal applications have, at the same time, widened the increment between the properties of seal materials measured at room temperature and the realistic properties which these materials exhibit under actual service conditions. This factor is separate from heat stability of such materials which is commonly evaluated by change in properties after extended heat exposure. It is due rather to the decreasing strength characteristics of the materials at increasing environmental temperatures.

Tests to determine the functional properties of silicone-rubber seals at environmental temperatures show a considerable degree of correlation between composition and performance of seal materials. Properties covered are compression set, compression-deflection, and polymer reversion. Table 1 shows properties of compounds tested.

Compression Set: This is an inverse measure of the ability of a rubber part to retain effective sealing characteristics. The lowest possible value for this property is to be desired. Two major environmental factors affect compression set of elastomeric materials — time and temperature, Table 2. Compression set is substantially greater after 70 hr than after 22 hr at 350 F for low-compression materials. The seemingly impossible values for compound A are not unrealistic for this type of high compression-set silicone rubber. In addition to taking a 100-per cent set, specimens underwent heat shrinkage so that final

Table 1—Properties of Silicone-Rubber Compounds

Silicone Polymer	Filler Material	Shore Hardness, A Scale		Tensile Strength (psi)		Elongation (per cent)		Tear Strength (lb per in.)
		Rm. Temp.	70 hr, 500 F	Rm. Temp.	70 hr, 500 F	Rm. Temp.	70 hr, 500 F	Rm. Temp.
Dimethyl	Mineral	60	*	450	*	150	*	40
Dimethyl	Diatomaceous silica	70	85	600	420	70	50	30
Methyl vinyl	Aerogel and diatomaceous silicas	70	76	850	675	100	60	45
Methyl vinyl	Precipitated and diatomaceous silicas	70	75	800	690	110	90	50
Methyl vinyl	Fumed and diatomaceous silicas	70	75	850	640	125	60	75
Methyl vinyl	Fumed silica	70	75	900	640	175	100	100

*Data not available.

thickness dimensions were actually less than those to which the specimens were originally compressed.

The lowest compression set was obtained with methly-vinyl base compounds containing precipitated silica (compounds C and D). At temperatures above 350 F, however, these silica-filled rubbers failed to retain their superiority. Compression set increases with temperature and is influenced by the type of fillers. Also, there is a more pronounced effect of temperature on compounds containing precipitated silica than on corresponding compounds containing fumed silica. Thus, at temperatures below 375 F, precipitated-silica filled stocks have better compression set than do corresponding fumed-silica filled compounds. At 400 F and above, superiority of the fumed-silica filled compounds becomes increasingly pronounced. The high compression-set obtained for compounds containing precipitated silica is believed to be related to their inferior confined-heat characteristics.

Stocks compounded with fumed silica have lower compression set to about 400 F than compounds containing a mixture of fumed and diatomaceous silicas. Above this temperature, the two are essentially equal. The relative temperature insensitivity of compounds containing diatomaceous silica with respect to compression set may contribute to this relationship. The lowest compression set is attained in the approximate hardness range of 55 to 70 Shore Durometer, A scale. Again, there is the reversal in superiority of compounds containing precipitated silica and fumed silica with increasing temperatures. Data also suggest a temperature limitation of 450 to 500 F for extended operation of silicone-rubber seals since the compression set of even the best compounds attains or exceeds 100 per cent in this temperature range for 70-hr tests.

Compression - Deflection: These tests measure the stress-strain properties of a material under compression and are used more commonly for evaluating plastics. Tensile stress measurements have been somewhat conventionally employed with elastomeric compounds. However, preliminary tests conducted on silicone rubber stocks for compressive and tensile stress characteristics indicate no uniform correlation between these two properties. Compression - deflection characteristics were selected for study on the basis that they more nearly simulate one major functional requirement of seals. Tests for this property were confined to methyl-vinyl base compounds with various fillers and curing systems because they were more readily procured and for reasons of superiority already discussed.

Examination of curves showing the effect of compressive loading on deflection of some typical silicone-rubber compounds at room temperature reveals an approach to a straight-line relationship up to approximately 20 per cent deflection. Beyond this point, there is a progressive acceleration of increased deflection with increase in compressive loading. A distinct break occurs in the curves at approximately 20 per cent deflection. This effect is much less pronounced at elevated temperatures because of the greater deflection of the materials at these temperatures even under low compressive loads. It is interesting to note that this transition point coincides closely with the optimum assembly pinch (15 to 25 per cent) selected for static O-ring seals by aircraft engine designers based on performance experience.

Since hardness of silicone rubber is determined by the amount of filler, it can be expected that compressive stress and hardness will increase somewhat proportionately (provided other factors are constant) although the relationship is not a straight-line function. Also, compressive stress decreases rather slowly with increased temperature to about 350 F, but drops rather sharply above this temperature. It is more severely affected by temperature as hardness of the compound is increased. There is an extremely rapid loss of compressive stress with increasing temperature for compounds reinforced with diatomaceous silica fillers. The effect is even more pronounced for compounds containing fumed and diatomaceous silicas than for those with precipitated and diatomaceous silicas.

Table 2—Compression Set of 70-Durometer Silicone-Rubber Compounds*

Silicone Polymer	Filler Material	Compression Set (per cent) Time → 22 hr	70 hr
A. Dimethyl	Diatomaceous silica	105	105
B. Dimethyl	Diatomaceous silica plus low compression-set additive	25	55
C. Methyl vinyl	Precipitated and diatomaceous silicas	15	20
D. Methyl vinyl	Precipitated and diatomaceous silicas, butyl peroxide catalyst	12	18
E. Methyl vinyl	Fumed and diatomaceous silicas	19	25

*At 350 F.

Table 3—Polymer Reversion of Silicone Rubbers

Silicone Polymer	Filler Material	Shore Hardness, A Scale at Room Temperature	Loss of Hardness (per cent) At 400 F	At 450 F	At 500 F
Dimethyl	Diatomaceous silica	70	0	0	3
Methyl vinyl	Diatomaceous silica	85	1	8	18
Methyl vinyl	Precipitated and diatomaceous silicas, benzoyl peroxide catalyst	72	8	42	72
Methyl vinyl	Precipitated and diatomaceous silicas, butyl peroxide catalyst	73	3	30	70
Methyl vinyl	Fumed and diatomaceous silicas	84	1	4	11
Methyl vinyl	Fumed silica, butyl peroxide catalyst	81	0	2	4

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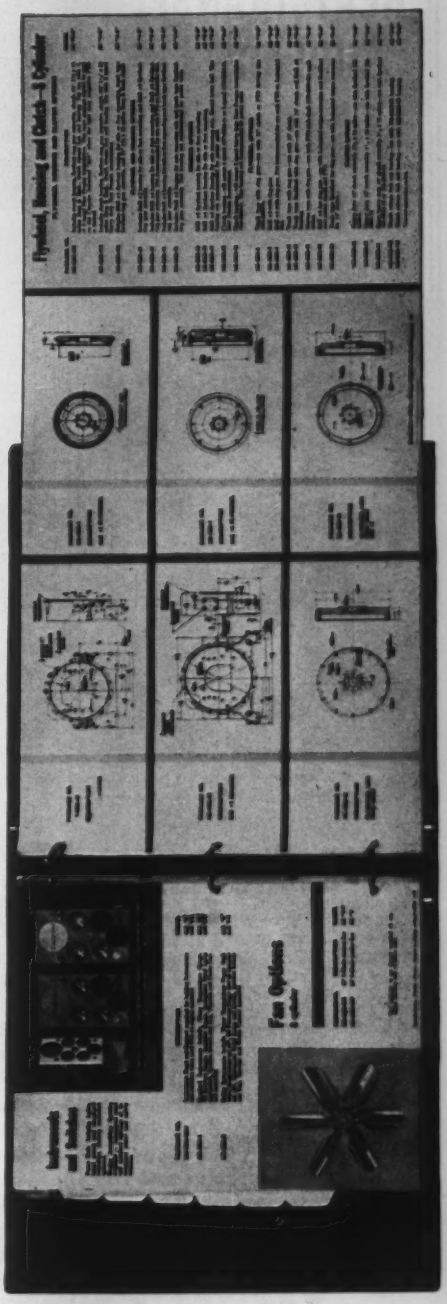

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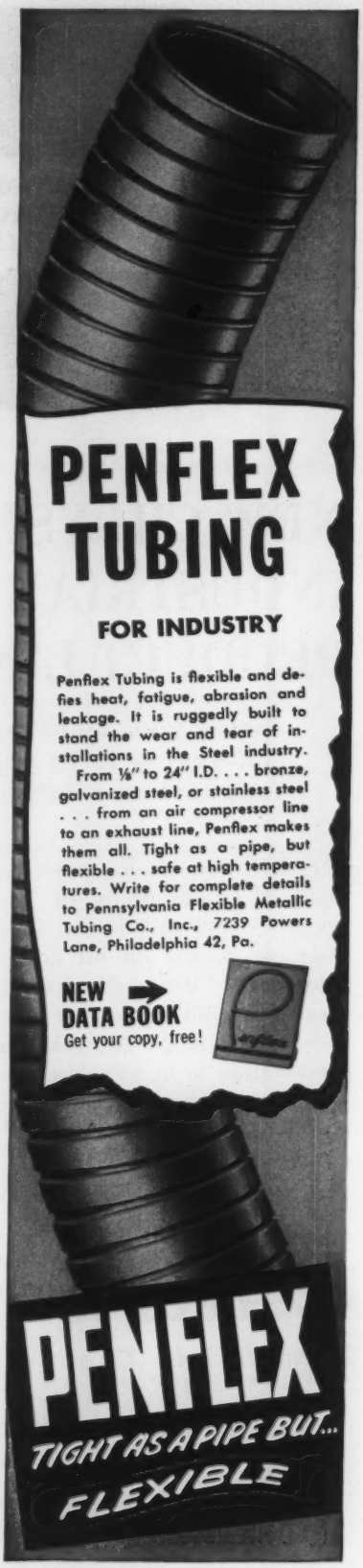
Compressive stress is believed to have a significant relationship to the performance of elastomeric materials for seals. One conclusion is that a 20 per cent compressive stress of 400 psi minimum is necessary for satisfactory seal life. However, few of the silicone rubber compounds tested exhibit this high a compressive stress. No quantitative relationship has been established between compressive stress and service life for silicone-rubber seals, but there has been striking evidence that high compressive stress contributes to improved service life. This has been especially true for seals of the type used in flexible fittings for rigid pipe connections subject to high compressive loads.

Confined-Heat Properties: One undesirable property not commonly found in most other synthetic elastomers has been observed in many silicone-rubber compounds. This property is frequently referred to as polymer reversion. Silicone rubber behaves conventionally when exposed to high temperature in an unconfined state, gradually hardening and losing strength and elasticity. On the other hand, when it is heated while closely confined, as in a tight container, it tends to soften and become plastic. In extreme cases it attains a putty-like state.

The mechanism is believed to be one of volatility. Small quantities of volatile breakdown products resulting from heat exposure leave the part relatively unchanged if allowed to escape. If, however, these products are confined in contact with the part, they react with it and produce a deteriorated product. This phenomenon is usually associated with compounds which are not completely neutral but contain a small excess of acid of alkali.

The effect of alkalinity is strikingly demonstrated by a comparison of silicone-rubber compounds containing precipitated silica and fumed silica fillers, Table 3. Reversion is decidedly more pronounced for stocks with precipitated silica. Compounds containing Aerogel processed silica have a similar but less-pronounced confined - heat effect. The reversion tendency of methyl-vinyl gum compounds filled with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#3
INGENUITY: Key to Successful Honeycomb Sandwich Design

In most actual honeycomb sandwich applications the success of the design is a direct measure of the ingenuity of the designer. The reason for the heavy dependence on the designer's resourcefulness is that the details of such light weight composite materials require many unusual innovations in order to carry in loads which are higher than can be normally sustained by the overall structure.

Typical of such problems is the design of an attachment point, or tie-down fitting, in the middle of a sandwich floor. Figure 1 illustrates a satisfactory design wherein the material tie-down fitting is accomplished through a wooden block which distributes concentrated loads created by the fasteners. Figure 2 illustrates another load distribution technique utilizing a molded or poured plastic block.

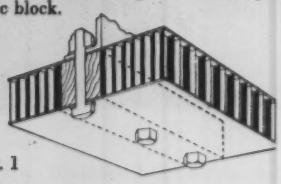

Fig. 1

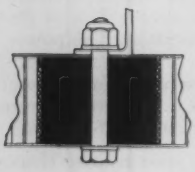

Fig. 2

A large diameter washer under the bolt head will further aid in load distribution.

Edge Details

The edges of a sandwich structure are not normally required to be sealed off for environmental purposes since most core materials are resistant to normal atmospheric exposure. It usually is imperative, however, to close the edges off to prevent incidental damage to the core and to provide strengthening of the sandwich to carry edge attachment loads. Sketches of typical edge details are shown in Figure #3.

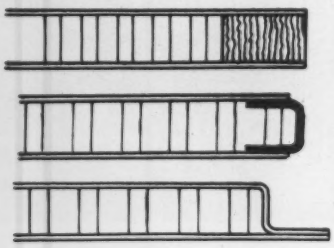

Fig. 3

A simple inspection of the various means shown should provide an idea for a method suitable for a design capable of meeting any specific edge loading.

Adding Strength in Critical Areas

In many designs it is desirable to have the overall light weight of a sandwich structure, but it is still necessary to meet extremely high load requirements in some localized areas. These conditions can be met by using a high density honeycomb in the local area, by adding doublers under the skin, or by the use of various composites of inserts as shown in Figure #4.

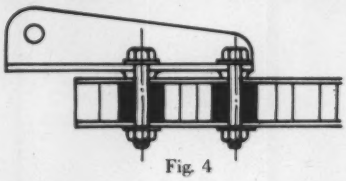

Fig. 4

These design types are typical of those being used today in designs which permit an improvement in strength-weight ratio of four to ten times.

Such results signal even greater achievements ahead as designers become more intimately familiar with the design opportunities offered by composite honeycomb structures.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

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diatomaceous silica are also somewhat greater than those filled with fumed silica. Results are intermediate for compounds containing mixtures of the two fillers. By contrast, dimethyl gum compounds with diatomaceous silica show remarkably good reversion resistance. This emphasizes the fact that polymer reversion is not necessarily caused by any one ingredient but is rather a function of the degree of neutrality attained in the finished and cured compound.

Polymer reversion is strictly a high-temperature phenomenon. Below 400 F, reversion is almost negligible for any of the compounds. Tests above 500 F have resulted in severe reversion of all compounds. Reversion may account for the unsatisfactory behavior of silicone-rubber compounds in jet-engine oil. Their resistance to this is moderately good to approximately 300 F. At higher temperatures they deteriorate in much the manner observed in confined-heat tests.

This deterioration is not a bulk-oil effect, but can occur in the presence of even small quantities of oil vapors with the severity of deterioration increasing with temperature. Jet-engine oil is composed essentially of diesters which are likewise subject to deterioration in this same temperature range, forming, among their breakdown products, dicarboxylic acids. It is believed likely that these acids cause the observed deterioration of silicone-rubber materials by upsetting their neutrality in the same manner as do acid or alkaline constituents in the compounds.

SAE paper 50V, SAE National Aeronautic Meeting, New York, April, 1959; 28 *pp.*

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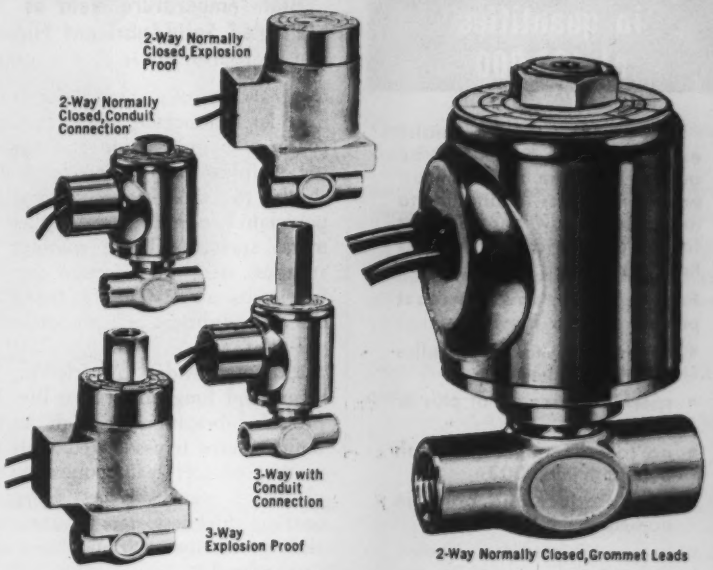
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moving and static joints, and review of maintenance practices. Each is discussed in detail.

ASLE paper 59AM 2C-2, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 8 *pp.*

Using Hydraulic Oils and Fire-Resistant Fluids

K. W. Zintz, The Hoover Co.

General recommendations for selecting hydraulic fluids for use in various machine systems. Optimum performance of such fluids is based on fluid selection according to properties, temperature control, design of hydraulic systems and reservoir, and adequate maintenance.

ASLE paper 59AM 1B-2, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 6 *pp.*

lubrication

High-Temperature Wear of Bonded Solid-Lubricant Films

R. L. Johnson and H. E. Sliney, NASA

Development of a method for bonding lead-monoxide base ceramic coatings to martensitic and austenitic stainless steels. The method is similar to a fusion process in which porcelain enamels are applied to metal surfaces. These coatings for stainless steel are effective dry-film lubricants at 1250 F. Thickness influences lubricating properties of the film, and a coating of 0.001 in. thickness provides low friction, low wear, and long endurance life. Improved lubrication at high surface temperatures is associated with formation of soft lead-monoxide base glazes on wear surfaces. Effects of coating thickness, temperature, and sliding velocity on friction and wear are covered.

ASLE paper 59AM 1A-4, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 14 *pp.*

Viscosity of Lubricant Films Under Very Low Shear Rates

E. K. Gatcombe, R. P. Hunnicutt, and G. F. Kinney

Interferometer measurements of the thickness of lubricant films under load. Measurements indicate that wall forces at the lubricant-solid interface have negligible influence on fluid viscosity as long as there

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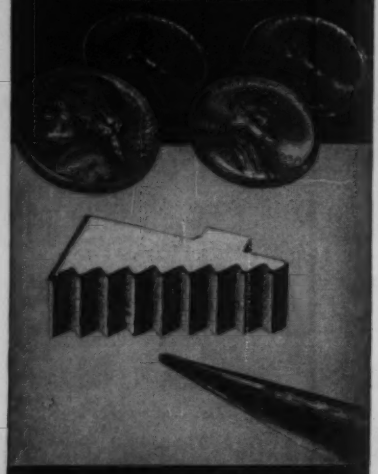

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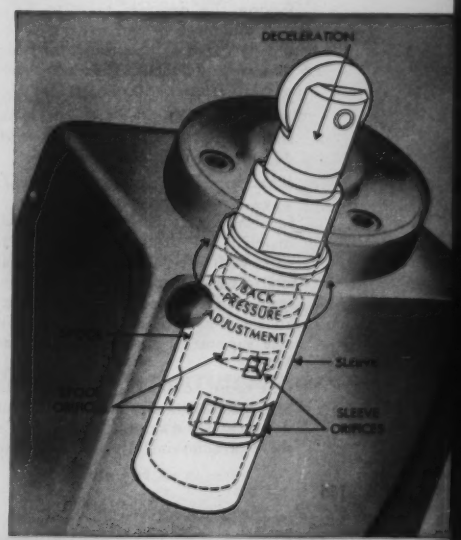

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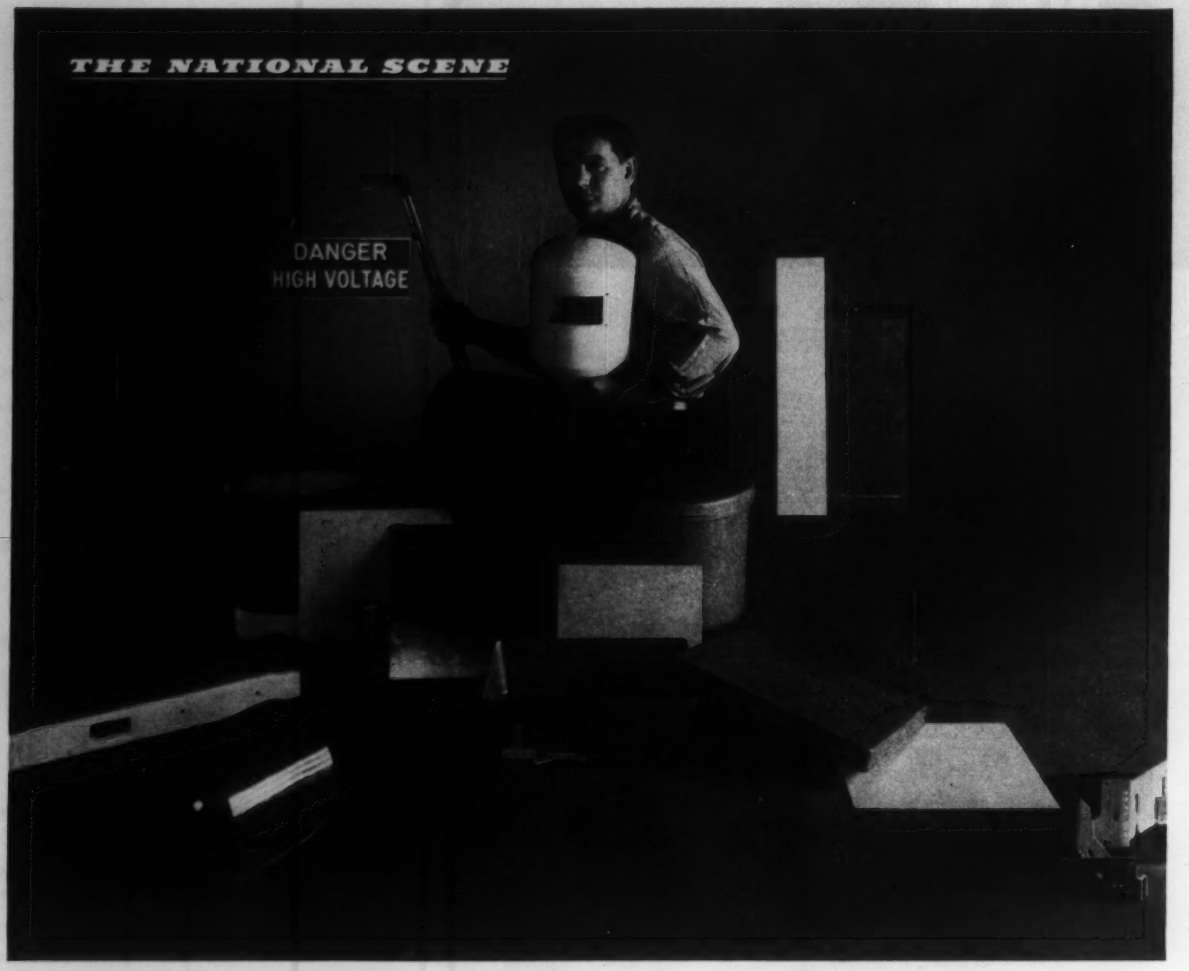

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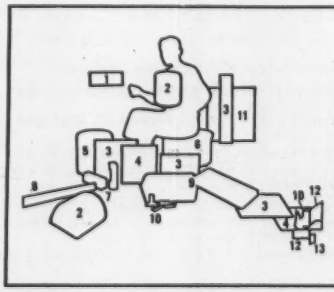

1. Silk screened sign, polyester sheet. 2. Molded weldor's helmets. 3. Polyester sheet, natural. 4. Polyester sheet, black. 5. Molded radome cover for traffic radar detector. 6. Molded explosive powder bucket. 7. Molded photographic film splicer housing. 8. Machined circuit breaker support bar. 9 Molded tray & lid. 10. Punched terminal boards. 11. Molded bread tray. 12. Punched electric arc suppressor. 13. Machined cam block.

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is appreciable bulk movement of fluid or while the lubricant is in the form of relatively thick film. In very thin films and at low shear rates, however, an increase in apparent viscosity of the lubricant is noticeable. As a result of this increased resistance to flow, lubricant films can, in some circumstances, be maintained even at zero shear. Behavior of this film may be of importance in the lubrication of gears at the pitch line where there is no shear.

ASLE paper 59GF-10, *ASLE First Gear Symposium, January,* 1959; 11 *pp.*

Lubrication of Solids At High Temperatures

B. L. Mordike, University of Cambridge, England

Recent developments in high-temperature lubrication. Three main sections of the paper deal with friction of lamellar solids, lubrication from the gas phase, and frictional properties of hard metals at high temperatures. Observations during the tests conflict with theories of the lubricating properties of lamellar solids, particularly graphite. Graphite is reported to show an increase in tensile strength with an increase in temperature but a decrease in friction. Conclusions indicate that conventional lubricants are useless at high temperatures. Although graphite may still provide some protection at these temperatures, it may be much simpler to use a dry bearing of a suitable hard metal. Carbides were investigated for this purpose.

ASLE paper 59AM 1A-3, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 14 *pp.*

materials

New Applications of Lead Powders

R. L. Ziegfeld, Lead Industries Assoc.

A brief report on the production status of wrought-lead products. Preliminary work shows that thin sheet-lead can be made from lead powder and has approximately twice the tensile strength of similar sheet lead produced by conventional casting and rolling methods. Tests also indicate that strength is retained at

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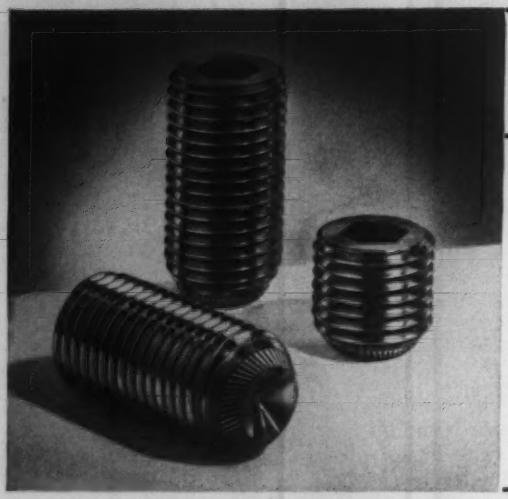

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Screw Size	Unbrako	Set Screw B	Set Screw C	Minimum Differential %
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#5	9	7.8	7.4	15
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#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

High torque UNBRAKO socket sets are available as follows: Sizes, #0 through 1 in.; materials, alloy steel and 18-8 stainless steel; Types, plain cup point (microsizes and stainless)—self-locking with knurled cup point (#4 through 1 in.)—self-locking with Nylok (plain cup point).

High Torque UNBRAKO socket set screws have up to 40% more holding power

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High torque UNBRAKO socket set screws are stocked by authorized SPS industrial distributors. Ask the one nearest you for complete details. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

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Circle 495 on Page 19

much higher temperatures than in the case of ordinary lead. The effect of mixing nonmetallic materials with lead powder to produce mechanical parts is covered briefly. Mixtures of lead powder and epoxy resins are commercially available for a variety of applications. Such mixtures provide excellent metal-to-metal bonds and bonds between metals and many other materials. Other applications are suggested.

MPIF Paper, MPIF Fifteenth Annual Meeting, Detroit, Mich., April, 1959; 5 *pp.*

Leaded Ceramics for Electronic Components

A review of high-performance porcelain capacitors for the electronics industry. These capacitors use lead-boro silicate vitreous enamel as the dielectric material. They are monolithic bodies with silver electrodes integrally fused within the porcelain. The capacitors are used in guidance systems, fire-control systems, high-speed computers, communication gear, telemetry components, fuse systems, and in all airborne missiles and many conventional aircraft. Of significance in many of these applications is the extremely low dielectric loss of the component. Other electrical properties are tabulated.

Lead, *Vol.* 23, *No.* 1, 1959; *pp.* 7-8.

A New Look at the Refractory Metals

Review of the latest developments in applications and fabrication of tungsten, tantalum, molybdenum, and columbium alloys. Mechanical and physical properties and corrosion resistance of the alloys are compared.

Fansteel Metallurgy, March, 1959; 8 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 35 cents to members, 50 cents to nonmembers.

MPIF—Metal Powder Industries Federaton, 130 W. 42nd St., New York 36, N. Y.

Lead—Lead Industries Assoc., 60 East 42nd St., New York 17, N. Y.

Fansteel Metallurgy, Fansteel Metallurgical Corp., Metals & Fabrication Div., North Chicago, Ill.

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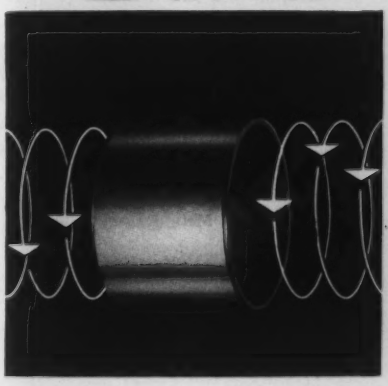

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Hydraulic Accumulators

Built to ASME, JIC, Coast Guard, and Mil specifications, line of hydraulic accumulators described in Section AC110-02-2 includes sizes to 10 gallons for service pressures to 3000 psi. Design details are included. 6 pages. American Bosch Arma Corp., American Bosch Div., Springfield, Mass. B

Circle 601 on Page 19

Cemented Carbides

"Characteristics of Kennametal" is title of Bulletin B-111-A covering mechanical properties, applications, grades, and design suggestions relative to Kennametal cemented carbides. Available in standard rectangular blanks, discs, rods, tubes, and flats, Kennametal can be pressed and extruded in any special shape. 22 pages. Kennametal Inc., Latrobe, Pa. G

Circle 602 on Page 19

Hydraulic Packings

Information provided in Bulletin P-333 on homogeneous and fabric reinforced hydraulic packing encompasses design, construction, sizes, applications, installation, proper usage and service, and temperature factors for V-rings, U-cups, and piston cups. 16 pages. Crane Packing Co., 6400 Oakton St., Morton Grove, Ill. I

Circle 603 on Page 19

Hose Couplers & Fittings

Available sizes of Quik-Koupler hose couplings and fittings, as well as technical data on industrial vinyl hose are provided in brochure. Coupler is available in 45 different sizes. Items are used for air, water, oil, and chemical service. 8 pages. Hofmann Engineering Co., 4022 W. 55th St., Chicago 32, Ill. J

Circle 604 on Page 19

Casters

Swivel plate and rigid plate truck casters with load capacities from 100 to 15,000 lb are described in condensed Catalog 159. Detailed information also covers spring-action, V-grooved, grease-sealed, and scaffold casters, floor truck locks, industrial wheels, sockets, and glides. 24 pages. Faultless Caster Corp., Dept. PR-74, Evansville 7, Ind. J

Circle 605 on Page 19

Electrical Tapes

"An Engineer's Discussion of the Functional Temperature Limits of Scotch Electrical Tapes" is title of Folder E-PETF. Information covers acetate, cotton, glass cloth rubber base adhesive, silicone adhesive, paper, polyester, polytetra-fluoroethylene, silicone, and vinyl tapes. 6 pages. Minnesota Mining & Mfg. Co., St. Paul 6, Minn.

Circle 606 on Page 19

Roller Bearings

Catalog PL-559 is a condensed full-line reference on nine principal lines of roller bearings. Bearing specifications, general features, size availability, and application data are provided. 16 pages. Rollway Bearing Co., Syracuse 4, N. Y. N

Circle 607 on Page 19

Epoxy Resins

Technical Data Bulletin 1 on Araldite epoxy resins covers properties, glass fiber reinforcement, mold preparation, manufacture of laminates, and mixing and curing procedures. Supplementary folder describes surface coating and structural applications. 16 pages. Ciba Co., Plastics Div., Kimberton, Pa. E

Circle 608 on Page 19

Electric Process Heaters

The complete line of Chromalox electric process heaters reviewed in Catalog 60 represents over 15,000 types to fit most heating needs. Application and technical sections aid in calculating heating requirements. Radiant, conduction, and convection heating units are covered. 64 pages. Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa. G

Circle 609 on Page 19

Ball Bearings

Dimensions and radial load capacities of Hoover deep groove ball bearings are highlights of Bulletin 110 which covers extra light, light, medium, and heavy series bearings. Cartridge and felt seal units are also covered. Bearings will carry radial, thrust, and combined loads. 12 pages. Hoover Ball & Bearing Co., 5400 S. State Rd., Ann Arbor, Mich. H

Circle 610 on Page 19

Phosphor Bronze

Properties and other information on phosphor bronze wire, bars, rods, strip, sheets, and circles and special shapes are presented in illustrated brochure. Flexograin fine grain phosphor bronze available in all grades of strip is also detailed. 20 pages. H. K. Porter Co., Riverside-Alloy Metal Div., Riverside, N. J. E

Circle 611 on Page 19

Small Machinery Drive

The quiet running, vibration-free Poly-V Drive J for small diameter sheaves and short centers on small machinery is described and illustrated in Bulletin M142. It incorporates a parallel V-ribbed belt running in space-saving sheaves. Specifications are given. 4 pages. Raybestos-Manhattan, Inc., Manhattan Rubber Div., Passaic, N. J. C

Circle 612 on Page 19

Vinyl Plastic Tubings

Irvington vinyl plastic electrical insulating tubings for a wide range of electrical and electronic applications are subject of illustrated bulletin. Price list covering all sizes, properties chart, and technical data is included. 6 pages. Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. J

Circle 613 on Page 19

Stainless Steel Wire

Twenty-seven different types of ferritic, austenitic, ferritic-austenitic, and martensitic stainless steels available in cold drawn wire are described in illustrated Booklet UHB 580801. Tolerances, properties, and available sizes, finishes, forms, and applications are detailed. 77 pages. Uddeholm Co. of America, 155 E. 44th St., New York 17, N. Y. D

Circle 614 on Page 19

Cam Index Drives

Accurate, smooth, rapid, and shock-free indexing of heavy duty worktables on dial and trunnion type machine tools is provided by line of standard cam index drives. Technical data on 20 to 100-in. diameter sizes are found in Data Sheet 157. 2 pages. Expert Automation Machine Co., 17144 Mt. Elliott Ave., Detroit 12, Mich. H

Circle 615 on Page 19

Pressure Regulators

Two differential pressure regulators for controlling atomizing steam pressure at adjusted values higher and lower than fuel oil pressure are described in Bulletin Section IV. No. 1200 Type C and 1210 Type C units have 5 to 45 psi adjustment range. 2 pages. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 616 on Page 19

In-Line Pumps

Capacities to 260 gpm are available in this line of 1, 1½, 2, 3, and 5-hp in-line pumps which mount in the pipeline. As described in Catalog PIL-1, they can be installed horizontally or vertically for handling petroleum and other fluids. Operating and construction details are given. 6 pages. Red Jacket Mfg. Co., Box 270, Davenport, Iowa. I

Circle 617 on Page 19

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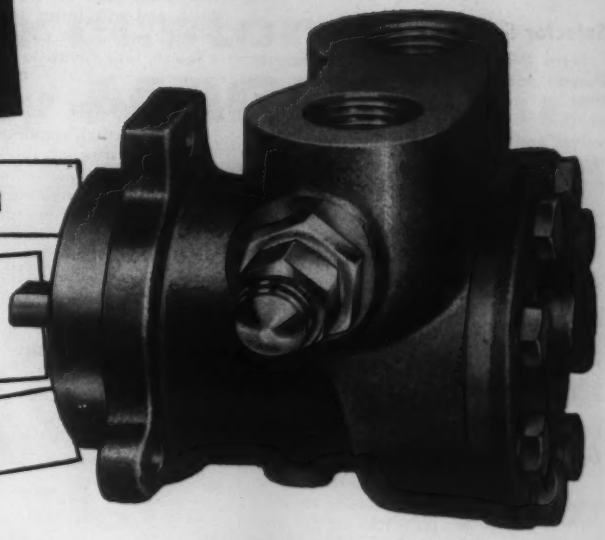

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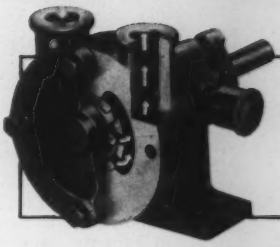


TUTHILL internal gear pumping principle

In Tuthill internal gear pumps, proven in 30 years of operation, there are only two moving parts. The principle is based upon the use of a rotor, idler gear and a crescent shape partition cast integral with the cover. Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the outside diameter of the rotor is sealed by the crescent. As the pump starts the teeth come out of mesh increasing the volume. This creates a partial vacuum drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and the rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

Tuthill Pump Company
953 East 95th Street
Chicago 19, Illinois

☐ Please forward information on LPF series
☐ Please have your representative call

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 497 on Page 19

Selector Switches

Form P-79 and Bulletin 357-2 describe Powers selector switches designed to deliver or stop a flow of compressed air, or direct the air to selected controlling valves and motors. 6 and 2 pages, respectively. Powers Regulator Co., 3434 Oakton St., Skokie, Ill. I

Circle 618 on Page 19

Fasteners

Ace Kwik-Nuts, offered for 1/4, 5/16, and 3/8-in. bolt sizes, and Ace torque washers for holding the square shoulder of carriage bolts, are shown in Bulletin 508. Various fastener tools are also shown. 2 pages. Frank L. Robinson Co., Latham Square Bldg., Oakland 12, Calif. M

Circle 619 on Page 19

Ground Fault Protector

Two-unit system for protection against ground faults and short circuits on direct current operated off-track mining machines and their trailing cables is the Lectronic Sentry, subject of Bulletin B74. Illustrations show its components and operation. 8 pages. Joy Mfg. Co., 1201 Macklind Ave., St. Louis 10, Mo. I

Circle 620 on Page 19

Slow Speed Motor

Low-noise helical gears and sealed-in protection against dirt are built into the Series F slow speed gearmotor. Speeds from 6 rpm and torque up to 40 lb-in. are offered, according to data sheet. 1 page. Brevel Products Corp., 601 W. 26th St., New York 1, N. Y. D

Circle 621 on Page 19

Side Plunger Switches

Four heavy duty side plunger limit switches, available in plug-in and permanent mount housings, are detailed on illustrated Data Sheet 161. Side plungers allow them to "lie down" in cramped quarters. Specs are given. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 622 on Page 19

Latching Device

Hook-Lock latching device for use on military cases and commercial containers lies flat against mounting surface when open or closed. It is described in illustrated data sheet. 1 page. Simmons Fastener Corp., N. Broadway, Albany 1, N. Y. D

Circle 623 on Page 19

Adhesives

Adhesives for bonding polystyrene to various materials of construction are covered in technical bulletin. Properties, uses, and application procedures are given for each of several products. B. F. Goodrich Co., Adhesives Div., 500 S. Main St., Akron 18, Ohio. F

Circle 624 on Page 19

Spring Alloy

Elgiloy cobalt-nickel spring alloy is corrosion resistant, has high efficiency, is nonmagnetic, and resists fatigue, temperatures to 1000° F, and set. Complete technical facts on this material in strip, rod, and wire forms are given in "Elgiloy Handbook." 24 pages. Elgin National Watch Co., Abrasives Div., Elgin, Ill. J

Circle 625 on Page 19

Molded Cups

Construction, recommended service, and available sizes of rubber and synthetic, leather, reinforced synthetic rubber, metal bonded and reinforced, and homogeneous molded cups for piston pumps, hydraulic service, and pneumatic equipment are service in Bulletin AD-145. 6 pages. Garlock Packing Co., 436 Main St., Palmyra, N. Y. N

Circle 626 on Page 19

Insulating Tubing

Hygrade Polytube B is a Class B polyester varnished glass fiber tubing which is compatible with the new high temperature wire enamels, glass-served magnet wire, and polyester resins. Illustrated bulletin presents properties and application data. 4 pages. L. Frank Markel & Sons, Norristown, Pa. E

Circle 627 on Page 19

Direct Current Generators

According to Bulletin 459, Kato heavy duty direct current generators are available in ratings ranging from 500 w to 40 kw for service ranging up to 250 v. Construction features are shown, and chart illustrates performance. 2 pages. Kato Engineering Co., Mankato, Minn. J

Circle 628 on Page 19

Gas Washers & Fans

Two illustrated Bulletins L-2 and L-4 deal with dynamic hot gas washers and high temperature fans, respectively. Washers clean even flame-hot gases and eliminate air pollution. Fans are tailored to capacity, pressure range, and service temperature needs. 4 pages each. Fuller Co., Catasauqua, Pa. E

Circle 629 on Page 19

Single-Turn Potentiometer

Data Sheet 1543 details the Series 5400 single-turn potentiometer with coils ranging from 100 to 115,000 ohms. They are available in linear and nonlinear versions. 4 pages. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Ave., Fullerton, Calif. L

Circle 630 on Page 19

Diaphragm Control Valve

Usable for steam, water, oil, gas, and chemical service, line of sliding gate and plate control valves described in Bulletin J-170 is available in 1/4 to 6-in. sizes. Capacity tables and engineering data aid in application. 8 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 631 on Page 19

Glass Sealing Wire

Data Sheet IND-21 describes copper-cored No. 52 alloy glass sealing wire. It is used as a glass-to-metal seal material in electrical and electronic equipment and components. Diameters of wire range from 0.01 in. up. 2 pages. Texas Instruments Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 632 on Page 19

Mercury Safety Switches

Dimensions and other application information on heavy duty mercury safety switches for use in hazardous and corrosive atmospheres are contained in Bulletin 800. Pushbutton and selector type operators are offered in one and two bottle 20-amp controls. 2 pages. Tigerman Engineering Co., 4332 N. Western Ave., Chicago 18, Ill. I

Circle 633 on Page 19

Thermistor Thermometers

Capable of measuring temperatures in the range of −328 to 845° F, Thermophil thermistor thermometers use wide range of probes for various services ranging from corrosive liquids to gases and solids. Illustrated folder gives full information. 6 pages. Atkins Technical, Inc., 1276 W. Third St., Cleveland 13, Ohio. F

Circle 634 on Page 19

Vibration Pickup

Suited for calibration measurements for both vibrators and vibration sensors, the 4-120 vibration pickup is sensitive to vibrations ranging from 40 to 1000 cps. Specifications are given in Bulletin 1575. 2 pages. Consolidated Electrodynamics Corp., 360 Sierre Madre Villa, Pasadena, Calif. L

Circle 635 on Page 19

Chassis Slides

Engineering, design, and specification data on Chassis-Trak slides for rack-mounted electronic equipment are contained in Folder CT-5781. Basic tilting, tilt-lock detent, and nontilting types are shown. 20 pages. Chassis Trak Inc., 525 S. Webster Ave., Indianapolis 19, Ind. J

Circle 636 on Page 19

Spring Steel Data

Physical data for users of cold-rolled high-carbon flat spring steels are featured in Catalog 579. Booklet illustrates manufacturing methods used by company and typical end products fabricated from flat spring steel. Conversion, weight calculation, and strip coil weight charts are provided. 28 pages. National-Standard Co., Athenia Div., Clifton. N. J. H

Circle 637 on Page 19

Laminated Plastics

Over 50 grades of Formica industrial laminated plastics for products from truck wheels to printed circuits are described in the illustrated "Designer's Fact Book." Chart compares the qualities of the most popular grades and lists materials by military specification number. Applications in addition to the primary use are given. 206 pages. Request on company letterhead from Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio. G

Electric Motors

Ratings from 10 to 150 hp are available in line of drip, splash, and weatherproof integral horsepower electric motors, subject of illustrated Bulletin SB 186. Dimensions and construction features are covered. 4 pages. Request on company letterhead from Marathon Electric Mfg. Corp., Wausau, Wis. K

Wherever your customers buy MACOMA...

Its performance and name are the same around the world

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for hydraulic systems

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils—soluble cutting oils for high-production metalworking

Shell Voluta Oils—for high-speed quenching with maximum stability

Shell Macoma Oils are available world-wide . . . assurance that your customers abroad will get the same performance from your equipment that your domestic customers rely upon.

Macoma® Oils are premium quality, fortified extreme pressure industrial gear oils. They provide superior high-load-carrying capacity and are particularly effective where overloading, severe shock-loading or general heavy-duty conditions exist.

Macoma Oils have these added built-in benefits: excellent resistance to oxidation, great adhesiveness, rapid separation from water. They are non-corrosive, non-foaming and have high stability in storage.

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

SHELL MACOMA OIL

the extreme pressure industrial gear lubricant

SHELL

Circle 498 on Page 19

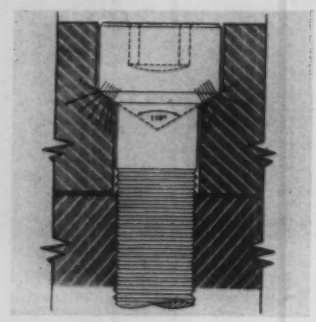
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Cap Screws

socket-head units have increased bearing surface

Socket-head cap screws, designated IB, incorporate a taper rather than a straight flange in head design, creating greater locking effect over previous units. Screws provide 16.66 per cent more bearing surface without increase in head size, and there is 14.28 per cent less resultant compression because of change in direc-



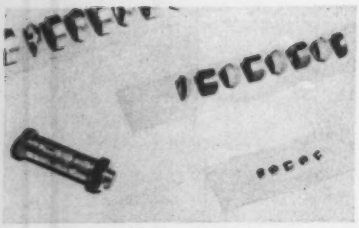
tion of stresses. Indenting or corner fatigue is eliminated. Screws are self-aligning and seal against leakage of oils, liquids, and gases. A standard drill machines matching 118-deg angle. Screws are available in all regular socket-head cap-screw sizes in No. 4 through 1½-in. diam. **Mac-it Parts Co.**, 275 E. Liberty St., Lancaster, Pa. E

Circle 638 on Page 19

Bushings

have adjustable wall thickness

Adjustable-wall-thickness bushing permits radial dimensions to be varied easily and exactly by a simple mechanical adjustment. Bushings consist of a series of alternate male and female segments aligned axially. Application of an axial compressive force to ends of bushing causes male segments to as-



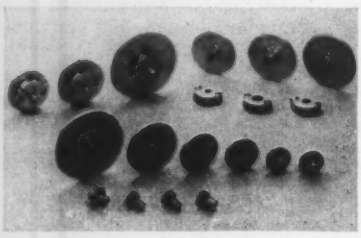
sume a smaller diameter, reducing ID of bushing. Female segments assume a larger diameter, increasing OD. All segments are slit axially through one wall to provide ease of adjustment. Decrease in ID and increase in OD results in a thicker wall for bushing. Typical applications include close-tolerance fasteners, hinge and pivot pins, replacing of taper pins and pressed-in-place pins, structural steel fabrication, and shaft clamps. Bushings are available in powdered metals, bronze, nylon, Teflon, stainless steels, and other materials. Units are designed to fit around bolts, pins, and shafts from 3/16 to 1 in. in size, and inside holes or bores with diameters from 5/16 to 1⅛ in. **Globe Bushing Corp.**, 12036 Vose St., North Hollywood, Calif. L

Circle 639 on Page 19

Precision Gears and Clamps

in ⅛, 3/16, and ¼-in. bore sizes

Clamp-hub-type precision gears and clamps are available in stainless steel and anodized aluminum in standard diametral pitches 40



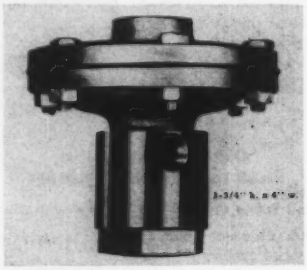
through 120. Consecutive tooth selection ranges from 20 through 120 teeth. Gears meet AGMA Precision Class 1 and 2 tolerances and are available in ⅛, 3/16, and ¼-in. bore sizes. **U. S. Gear Corp.**, 81 Bay State Rd., Wakefield, Mass. B

Circle 640 on Page 19

Miniature Valve

¼-in. unit is for control-air service

Miniature ¼-in. block and vent valve is designed for control-air service utilizing one operator. Air flow is straight through at operator pressures of 5.5 psi or greater. As operator pressure drops to 3.5 psi, air service is blocked. When pressure reaches 2 psi or less, cavity between blocked ports is vented to atmosphere. Body pressure rating is 30 psi, and body temperature rat-



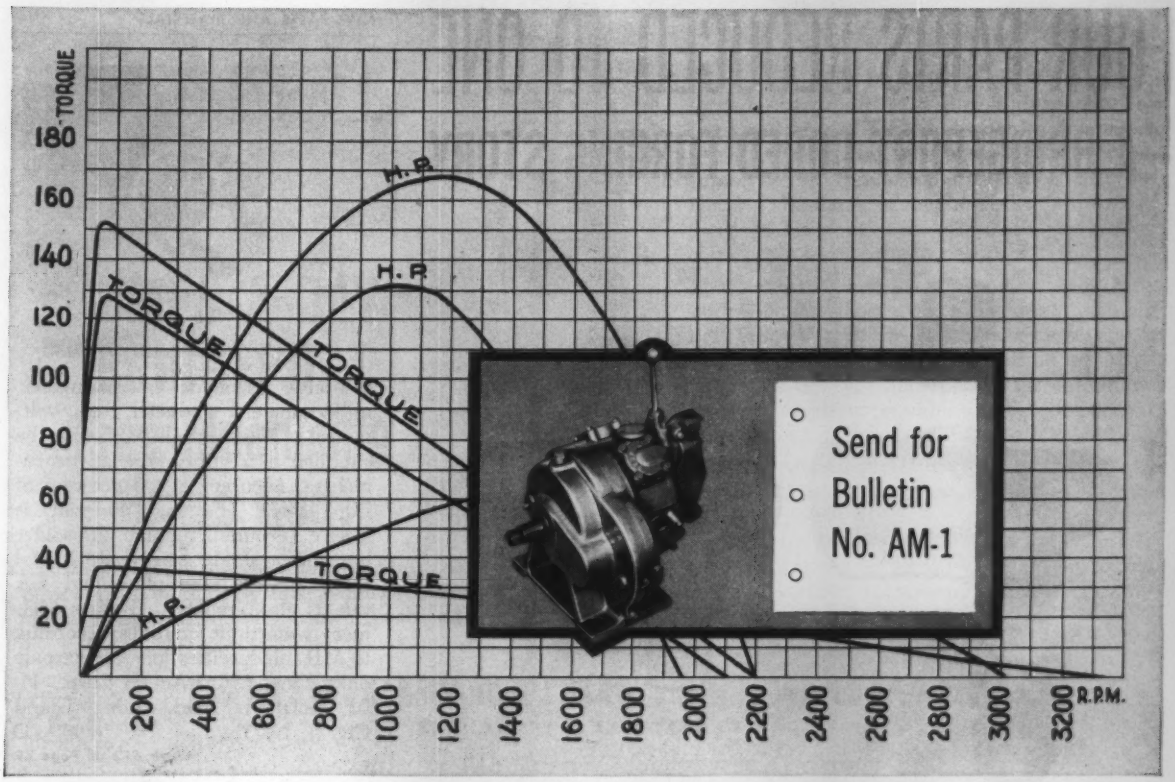
ing is for ambient air only. **George W. Dahl Co. Inc.**, 86 Tupelo St., Bristol, R. I. B

Circle 641 on Page 19

Panel Instrument

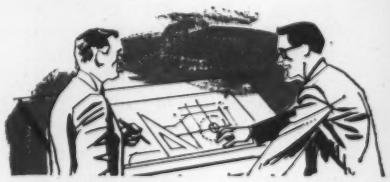
miniature meter has high accuracy

Microminiature panel instrument, Series SC-031, measures only 7/16 in. in diameter. The round, sealed unit includes an external pivot D'Arsonval movement and high flux density Alnico magnet. Meter is



Typical torque and horsepower curves for three sizes of Gardner-Denver 5-cylinder radial air motors.

Power curve proves high starting torque of this radial air motor



IN INDUSTRY—SPEEDING THE PACE,

the Gardner-Denver specialist is an integral part of the team. He works side by side with engineers and designers, helping to solve their problems, for at Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Here's a compact *air* power package that develops high starting torque and maintains smooth power under all speed and load conditions. Gardner-Denver's 5-cylinder radial design provides accurate counterbalancing and overlapping power impulses. At least two cylinders are always on the power stroke and three during part of the cycle. Heavy loads start easily . . . accelerate smoothly.

This Gardner-Denver air motor also offers control flexibility, vibrationless operation, high torque at any speed, freedom from overload damage and spark-free operation.

There are six Gardner-Denver radial air motors from which to choose, with power and speeds for a wide variety of applications. Sizes from 2 to 16 hp. Direct drive or built-in gear reduction. Reversible and non-reversible models. Put air power to work in your design. Contact your nearby Gardner-Denver representative for complete information.

GARDNER-DENVER Since 1859 100 1959 YEARS

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

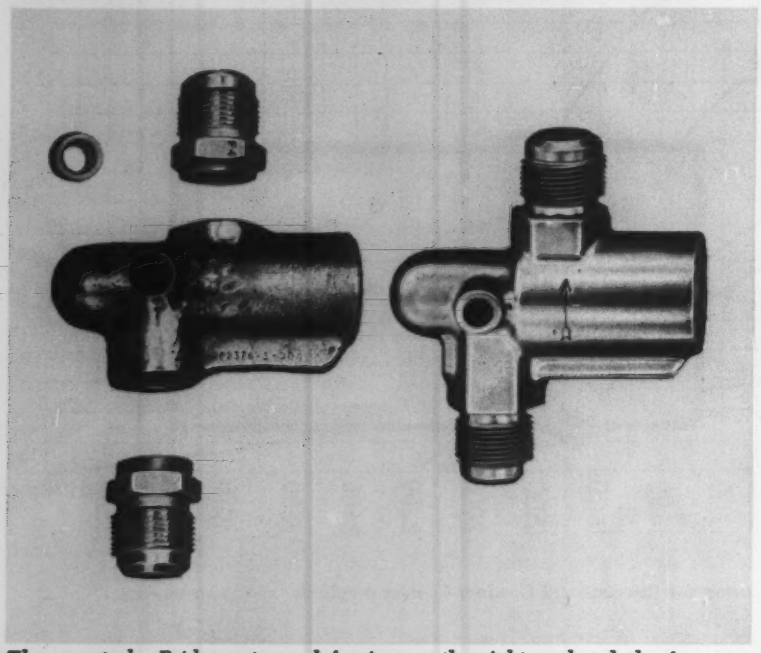
GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 499 on Page 19

FOUR PARTS REDUCED TO ONE
—A BRIDGEPORT CORED FORGING STORY



The one-stroke Bridgeport cored forging on the right replaced the four-part casting assembly on the left.

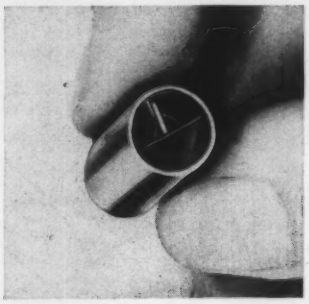
The purpose of these valves is to control liquid under pressure. The four-part assembly shown on the left did not operate to fullest efficiency. Leakage frequently was present because of the porosity in the part's cast element.

The Engineering Staff at Bridgeport's Cored Forging Division designed the economical one-piece cored forging pictured on the right to abolish — once and for all — the leakage problem as well as many of the production steps.

The control valve is now all one unit. Assembly time has been eliminated and inspection time and part porosity are things of the past. Good, positive chucking for threading operations has reduced machining time to the necessary minimum. This simple, yet significant achievement, is an example of what Bridgeport's forging processes, both die and cored, can do for your component or part. Learn more about Bridgeport's forging facilities.

Write to Dept. 8904 for your copy of our detailed 16-page brochure, "Bridgeport Forgings."

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium



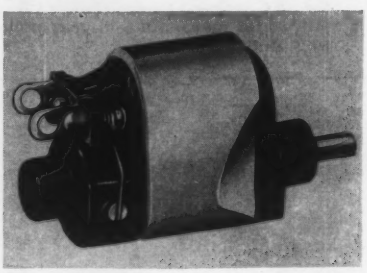
available as a dc microammeter, milliammeter, ammeter, or voltmeter. Two models can also be supplied as rectifier-type ac instruments. Accuracy is ±5 per cent of full scale. Housing material is steel. Terminals include one solder lug and a single wire lead. Model SC-030, with face plate and hex nut, is also available. Both models meet watertight qualities according to MIL-6b specifications. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 642 on Page 19

Miniature DC Motor

1.4-oz unit has high starting torque

Permanent-magnet dc motor achieves high starting torque at operating speeds higher than 20,000 rpm, in a unit weighing only 1.4 oz. Type 820 is available for operation on any specified dc voltage between 3 and 30, with armatures wound to produce any desired no-load speed between 5000 and 30,000 rpm at specified input voltage. Locked-rotor (maximum) torque is approximately 0.5 oz-in., with working torques ranging from 0.4 to 0.1 oz-in. between output speeds of 5000 and 20,000 rpm. With constant load, speed is almost a linear function of applied voltage, permitting accurate speed control by



ON THE BALL

500,000

TIMES A DAY BRIDGEPORT Free-Machining Brass Rod!

Because ball point pens are in everyday use, production of vital brass tips becomes astronomical along with quality control problems.

These tips — one of which is shown much enlarged — are produced at ultra-high speeds. The brass rod needed for them must be flawless in every respect. *Consistent* metallurgical composition, *precise* dimensional tolerances and *unvarying* standards of machinability — if any of these qualities vary even a fraction, production comes to a frequent and costly halt.

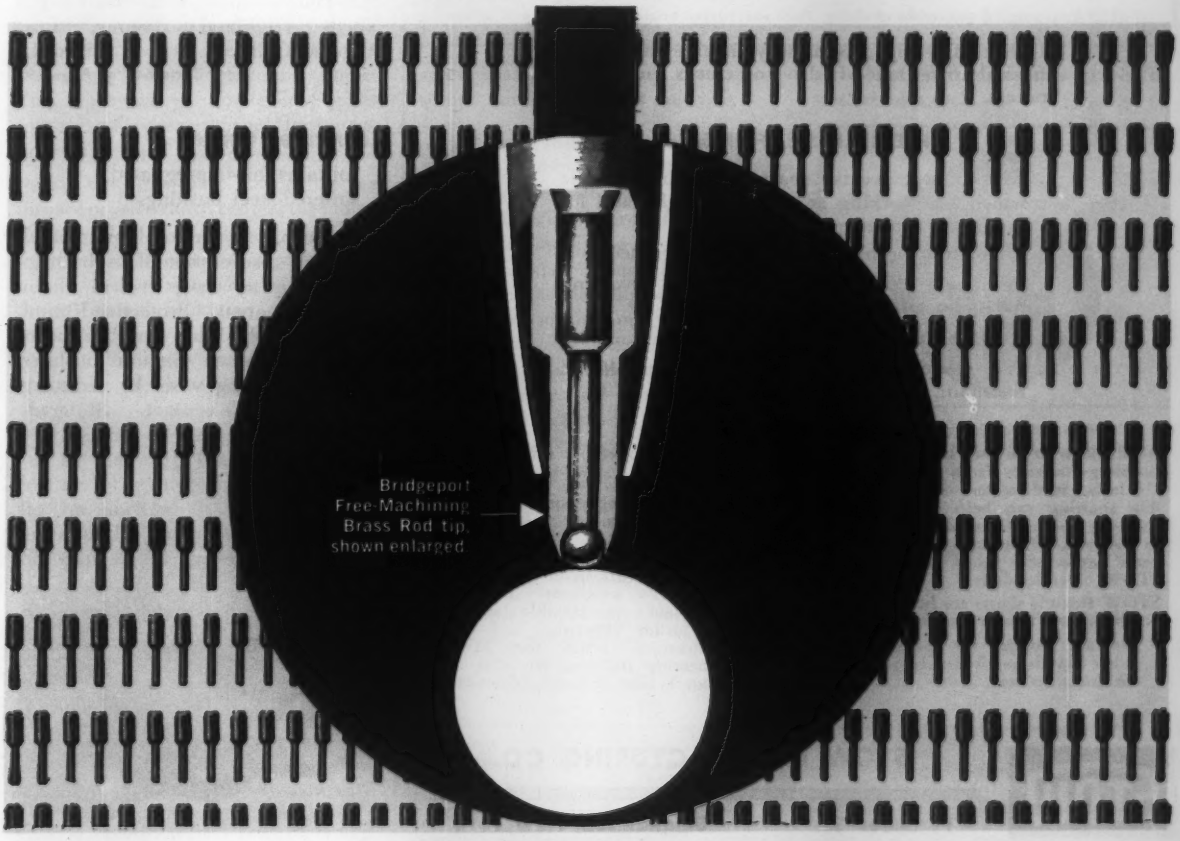
That's why Revere Metal Art Co., Inc., New York City, specifies Bridgeport Free-Machining Ball Point Pen Brass Rod for these inserts. It meets all requirements for precision, straightness, workability, machinability and tolerances —and, in addition, provides a surface finish that keeps finishing time and costs to a minimum.

Whether you use rod, strip or tube, you can count—just as Revere does—on getting consistent quality every time you specify Bridgeport Brass Alloys. It will pay you to get the complete story. Call your nearest Bridgeport Sales Office or write us direct for a complete list of Bridgeport products—Dept. 4305.

BRIDGEPORT BRASS COMPANY

BRIDGEPORT 2, CONNECTICUT

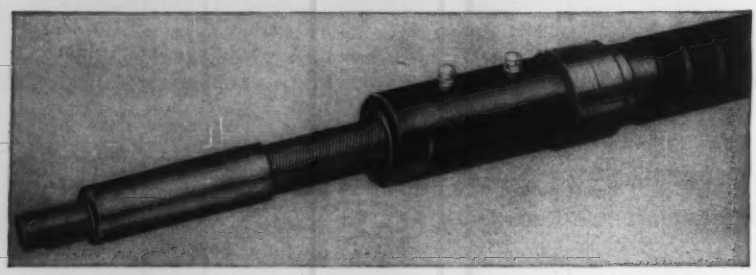
Specialists in Metals from Aluminum to Zirconium



Circle 501 on Page 19

STOW FLEXIBLE SHAFTING
The Ideal PTO Drive

1¼" flexible shaft under tractor-trailer transmitting 10 HP.



1¼" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from ¼ inch to 1¼ inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems *in advance.* The know-how of 82 years' experience goes into every STOW flexible shaft!

STOW flexible shafts are being used on trucks and tractor-trailers to:

- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.
- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

STOW

STOW MANUFACTURING CO.

11 Shear St. Binghamton, New York

varying input voltage below rated value. Motor is suitable for high-performance, intermittent duty in lightweight, portable equipment. **Cramer Controls Corp.**, Centerbrook, Conn. B

Circle 643 on Page 19

Pressure Switch

has no nonmetallic parts

All-metal Tier-Tube pressure switch eliminates all O-rings and other nonmetallic parts subject to aging and deterioration. The leakproof

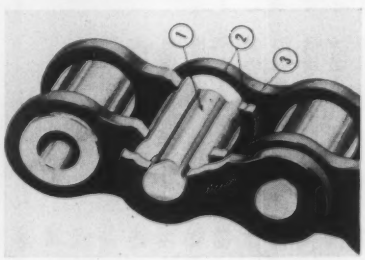
pressure capsule, coupled with a snap-action switch element, has extremely high temperature stability, contact pressure, and sensitivity. Switch has virtually unlimited life service and shelf life, and eliminates need for extensive overhaul and maintenance. **Meletron Corp.**, North Highland Avenue, Los Angeles, Calif. L

Circle 644 on Page 19

Lubricated Chain

contains oil-impregnated, sintered-steel bushings

MSL chain with oil-impregnated bushings assures complete built-in lubrication at three critical chain lubrication areas. Protective film of oil completely lubricates live bearing area between pin and bushing (1), minimizing wear by reducing metal-to-metal contact. Sintered-steel bushings extend beyond surface of inside plates (2) to act as lubricated thrust bearings, to control clearance, and to provide an oil cushion between plates, eliminating galling and seizing. Oil film on



Circle 503 on Page 19

electric motion control facts

for IDEA MEN

Combination clutch-coupling belt drive

Dream drive for tapping: simple, fast, automatic, and acutely sensitive

Here's one of those utterly simple and slightly "offbeat" solutions to a power drive problem that makes you wish *you'd* thought of it . . . and wonder why you didn't! We like to believe the flexibility of our electric brakes and clutches helps make dream drives like this one possible.

The problem was to provide forward and reverse rotation of a tapping spindle without the time delay, cost, and complexity of reverse gears . . . using a constant-running, unidirectional drive motor.

In arriving at a solution, engineers threw conventional thinking out the window. For forward, they mounted a Warner clutch-coupling to the drive motor in a split-shaft arrangement. For reverse, a round belt was run from a pulley on the motor shaft over an idler and down to a pulley and Warner clutch on the spindle. This ingenious, yet simple drive gives forward *and* reverse using only the round-belt and pulleys.

Here's how it works! Energizing the forward or drive clutch couples the motor shaft and lead screw, driving the screw and tap into the work. At a preset stop, a limit switch actuates a relay in the clutch control circuit, collapsing the forward clutch field and energizing the reverse clutch. This links the reverse sheave (driven by the same belt) to the lead screw shaft, withdrawing the tap. A second limit switch stops the cycle.

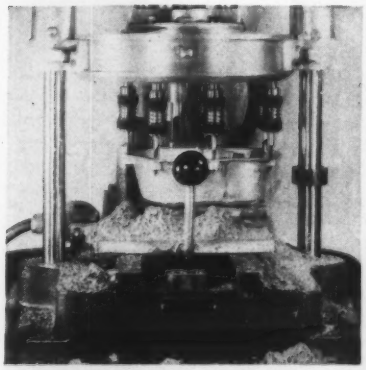


Fig. 1—*Electrical actuation* of Warner clutches permits shock-free, millisecond switching from "feed" to "retract," simplifies automatic cycling.

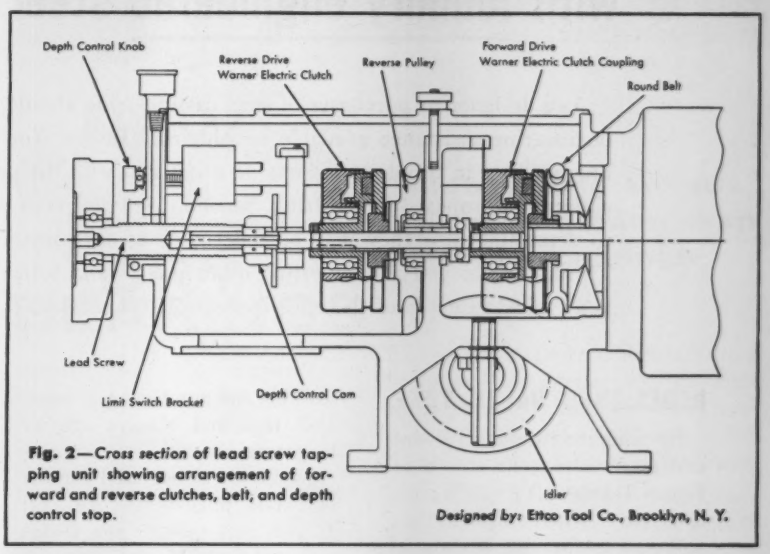


Fig. 2—*Cross section* of lead screw tapping unit showing arrangement of forward and reverse clutches, belt, and depth control stop.

Designed by: Ettco Tool Co., Brooklyn, N. Y.

Split-shaft application speeds cycling

Using forward and reverse electromagnetic clutches in a split-shaft application such as this means the drive motor can run continuously in one direction. With no time lost accelerating or decelerating the motor, millisecond operation of Warner clutches reduces cycle time, speeds production. And, since these clutches operate directly from actuating current, control hardware can be proportional to the work accomplished—you don't need a skid load of valves, cylinders, tubing, filters, etc., to "automate" a simple forward-reverse cycle.

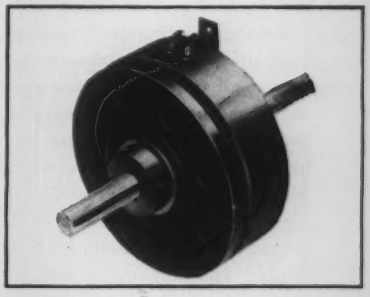


Fig. 3—*Stationary-field* clutches require no slip rings or brushes. Torque is transmitted through rotor and armature.

WARNER

Originators of electric motion control

Warner Electric Brake & Clutch Co.

Dept. MD, Beloit, Wisconsin

Gentlemen: Please send complete information about Warner electric brakes and clutches.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

THE DODGE STEEL Ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to obtain better, more efficient parts with foundry engineered steel castings

As a designer or purchaser of steel castings, you should know about the unique engineering assistance available to you from Dodge. You may take advantage of our facilities in three ways: First, to assist you with the proper design and specification of a proposed new casting; Second, to review your present castings in order to determine how they may be redesigned to save metal and increase strength; Third, to help you in converting other metals and forms to steel castings. Here is a typical example of the effectiveness of this service:

REDESIGNED VALVE YOKE

By using the redesigned Dodge cast steel valve yoke shown in Figure 1 below, Yarnall-Waring Company, Philadelphia, Pa., realizes a total saving in material and machining time of $15.81 per unit. And this excludes savings in tool and handling costs!

Before adopting steel castings, Yarnall-Waring Company machined all units. The yoke posts were made of #4140 material, and after machining, were heat treated for greater tensile strength. The heat treatment caused warping of the body and scaling of the threads—which in turn, made assembly and alignment difficult.

NEW ONE PIECE YOKE

Now, by using Dodge cast steel one piece yokes, Yarnall-Waring stocks one item rather than four. They save time across the board—purchasing, production, storage, handling and record keeping.

The change in design can be readily seen. Threaded yoke posts and nuts are eliminated, and the stocking and purchasing of seven 1⅛" taps and chasers are no longer necessary.

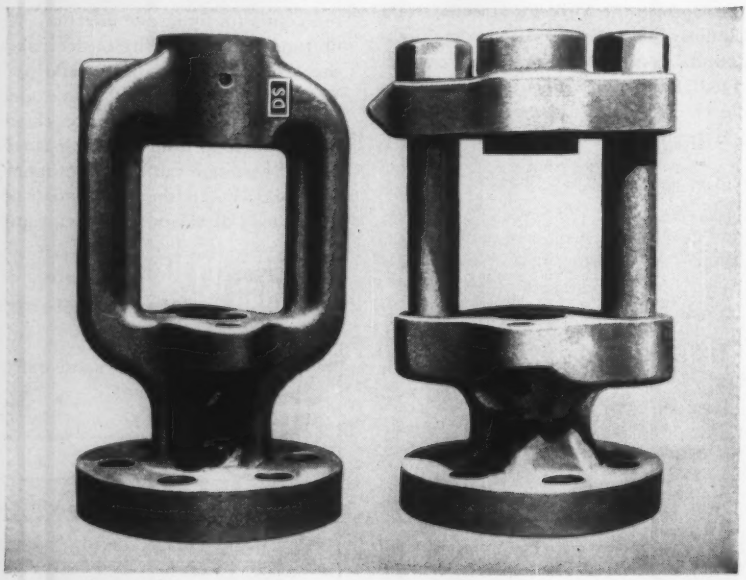
As for costs: material for the old style pillar-type yoke cost $17.58; material for the Dodge cast yoke, $8.32—a saving of $9.26! Machining time for the old style yoke cost $13.26, as compared to $6.71 for the Dodge Steel cast yoke—a saving of $6.55!

COMPLETE SERVICE

The best proof of the savings available to *your* company through the use of Dodge foundry engineering service is the experience of this manufacturer and others who have problems similar to yours. This timely and valuable service is ready to help you. May we study your problem?

Fig. 1 New Style

Fig. 2 Old Style



Circle 505 on Page 19

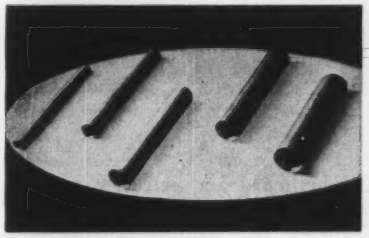
exterior surface of bushings provides constant lubrication between sprocket teeth and chain (3). Inherent material characteristics of sintered-steel bushings, and bushing configuration that provides greater contact area between bushings and links, permit high interference fit which preloads links and gives maximum fatigue resistance. Essential dimensions of standard and extended pitch MSL chain conform to ASA standards. **Whitney Chain Co.**, 303 W. Hamilton St., Hartford 2, Conn. B

Circle 645 on Page 19

Flexible Metal Tubing

in enlarged range of sizes and materials

Made with interlocked construction of strip metal in choice of thicknesses from 0.01 to 0.034 in., three grades of flexible metal tubing are available in galvanized,



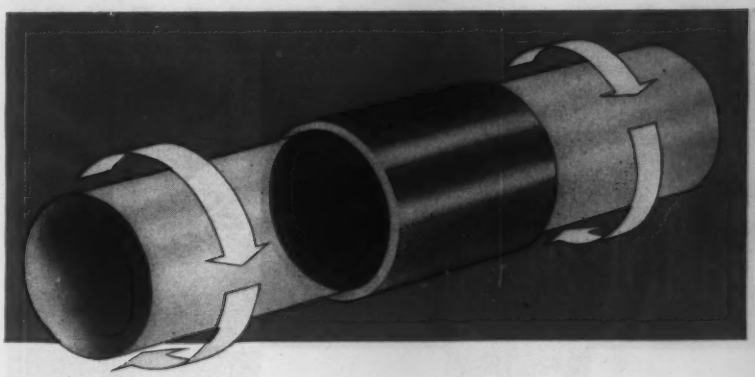
cold-rolled and stainless steel, and bronze. Various weights and metals are available to meet specific applications. **International Metal Hose Co.**, Bellevue, Ohio. G

Circle 646 on Page 19

Expansion Nut

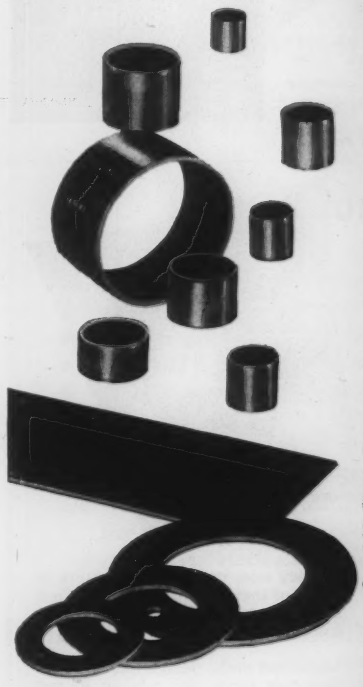
for fastening in sheet-metal assemblies

Quick-attachment expansion nut is available for multiple-purpose fastening applications where tapped holes are needed in thin sheet-metal assemblies used in appliance, automotive, and allied fields. Nut is furnished in six standard thread sizes from 1/4-20 to 3/8-24 and can be used in either hand or production-fastening operations. Fastener is a two-piece assembly, a nut held in a sheet-metal retainer having preformed tabs. Tabs of retainer fit into a panel having a prepierced square hole. Arched bars



NEW GLACIER DU DRY BEARINGS

allow sliding speeds 5 times greater than other dry bearings



DU's excellent thermal conductivity dissipates heat generated through sliding friction. Under low load conditions, for instance, applications for DU are on record up to 50,000 rpm.

Ideal on high load, low speed combinations, too. DU eliminates slip-stick where coefficient of friction is as low as .04. DU is a patented composite material consisting of a steel-porous-bronze interlayer impregnated with a lead-filled TFE* fluorocarbon resin. Withstands temperatures from −328°F to +536°F; has compressive strength of 51,000 p. s. i.

Apply DU to appliances, automobiles, aircraft, machinery, office equipment. Standard bushings and thrust washers stocked for 3/8" to 2" shafts; strip available for special fabrication. Find out more from your bearing manufacturer, or write for engineering Catalog DU-458.

SPECIAL PRODUCTS DEPT.
UNITED STATES GASKET COMPANY,
Camden 1, New Jersey

*Teflon, DuPont Trademark
Fluon, I.C.I. Trademark

THE GARLOCK PACKING COMPANY
Palmyra, N.Y.

United States Gasket

Plastics Division of GARLOCK

Circle 506 on Page 19

Neither dust, dirt, moisture nor temperature changes can affect an Adlake relay. Hermetically sealed mercury-to-mercury contact is quiet, chatterless . . . can't burn, pit or stick. A-plus qualities backed by a century of service. What's your control problem? Write today. No obligation.

a lot at stake?

NO. 1148, one of 4 basic models designed to your control needs.

SEND FOR FREE CATALOG J-8907
Adams & Westlake
Elkhart, Indiana

depend on A+ Adlake
mercury relays and controls

Circle 507 on Page 19

Remet Powdered Metal Part cuts DESIGN and MACHINING costs for Bonney Forge and Tool Works

R. L. Huston, Chief Engineer for Bonney, says, "We went to a powdered metal part on our shifter because the cost of machining this part from steel would have been prohibitive. Also, we would have had to change the entire design of our ratchet. We contacted no less than a dozen fabricators of powdered metal. Reese Metal Products Corp. was the only establishment able or interested in tackling this problem with us."

Bonney now uses Remet shifters in seven of their ratchets. The sintered Remet parts are copper infiltrated iron.

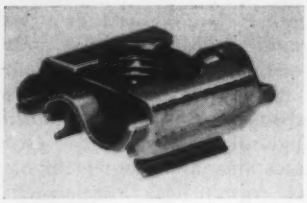
More and more design and production men each year rely on Remet services to help solve problems.

FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

Remet
REESE METAL PRODUCTS CORPORATION
837 Howard Ave., Lancaster 10, Penna.

Gears • Pinions • Cams • Ratchets
"Oilless" Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 508 on Page 19



at each end complete retainer. Nut can be attached to a panel without having to support the panel, permitting attachment at any assembly point in a process. Assembly tool for nut is portable, and can be operated manually, electrically, or pneumatically. Tool can be adapted for fixtures working in conjunction with automatic hopper feed of nuts. **McLaughlin Co.**, 212 Jaikins Bldg., Birmingham, Mich. H

Circle 647 on Page 19

Nonextruding Seal

for use under extreme extrusion forces

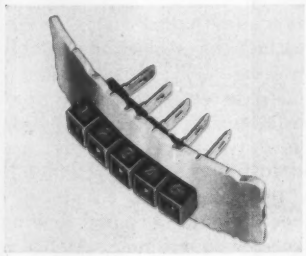
New seal, for use in special applications subject to extreme extrusion forces, is designated Quad-Bak. A variation of the Quad-Ring seal, it has one convex side for use when extreme extrusion forces act in one direction only. Seal is strengthened and extrusion damage to lips is eliminated. **Minnesota Rubber Co.**, 3630 Wooddale Ave., Minneapolis 16, Minn. J

Circle 648 on Page 19

Junction-Terminal Bushings

snap into curved and flat surfaces

Miniature Heyco junction-terminal bushings are accordion-type, nylon-insulated receptacles which mate with 3/16 and ¼-in. standard disconnect terminals. They snap into curved and flat surfaces, are available as single or as flexibly connected groups up to five, and are



number coded. Colors are available for color coding. Bushings eliminate pig-tail wire leads, screw terminals and junction blocks. They provide a neat appearance and quick disconnect access through housings. **Heyman Mfg. Co.**, 1200 Michigan Ave., Kenilworth, N. J. D

Circle 649 on Page 19

Check Valves

have flexible seal seat

Kepsel cartridge-type check valves incorporate a flexible seal seat which provides positive sealing action and extremely long life. Units are for use on subplate and manifold block assemblies, in pump suction inlets, pump conversions, and similar installations. Valves are leakproof at

all pressures, maintain low pressure drop at full flow, and eliminate all threaded connections. Standard cartridge is steel, equipped with Buna-N seal for use in general-purpose oils, lubricants, hydraulic oil, air, and water with working pressure to 3000 psi and surge flow protected. Units operate properly under temperatures of −40 to +300 F with cracking pressure of 1 to 2 psig. Valves can be adapted to many special-service requirements. **Kepner Products Co.**, 7361 W. 59th St., Summit, Ill. I

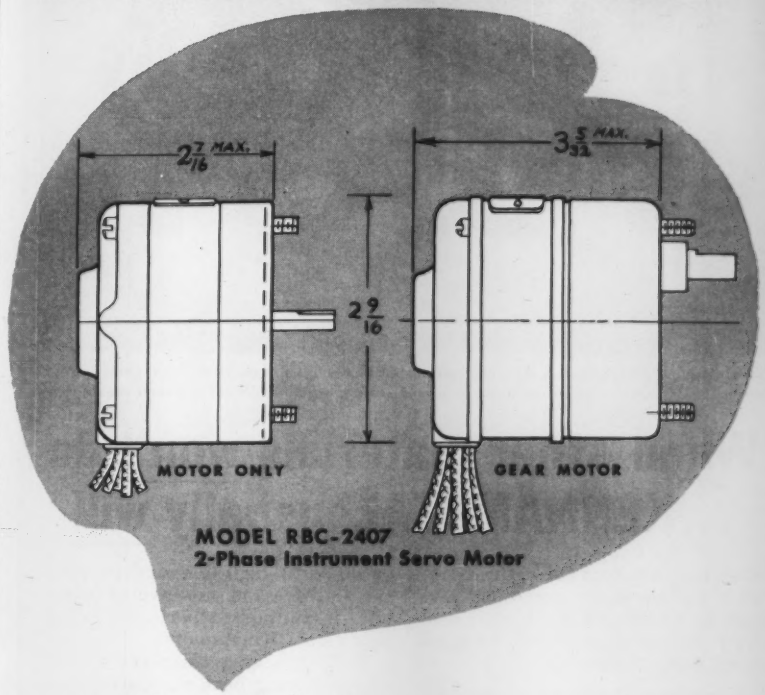
Circle 650 on Page 19

General-Purpose Relay

is clamped to supporting structure

Redesigned FC low-cost, general-purpose relay uses a one-piece metal clamp to fasten relay assembly rigidly to supporting structure in one operation, eliminating use of four screws. Fabricated phenolic washers are replaced with

HOLTZER-CABOT
offers these CUSTOM FEATURES in a new stock motor



- High torque-to-inertia ratio
- Torque to meet your needs
- Several output speeds to choose from
- Control winding impedance of 5400 ohms locked rotor
- New motor end cap design for easier mounting, better heat dissipation

The RBC-2407 is available as a basic motor or with four stock gear ratios to meet your application requirements. All gear motors are electrically and mechanically interchangeable. Send coupon for free bulletin covering complete details, including physical dimensions and electrical specifications of this Model RBC-2407 instrument motor.

HOLTZER-CABOT MOTOR DIVISION • NATIONAL PNEUMATIC CO., INC.

Sales-Service Representatives in Principal Cities throughout the World

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

HOLTZER-CABOT MOTOR DIVISION, Department MD
National Pneumatic Co., Inc., 125 Amory St., Boston, Mass.

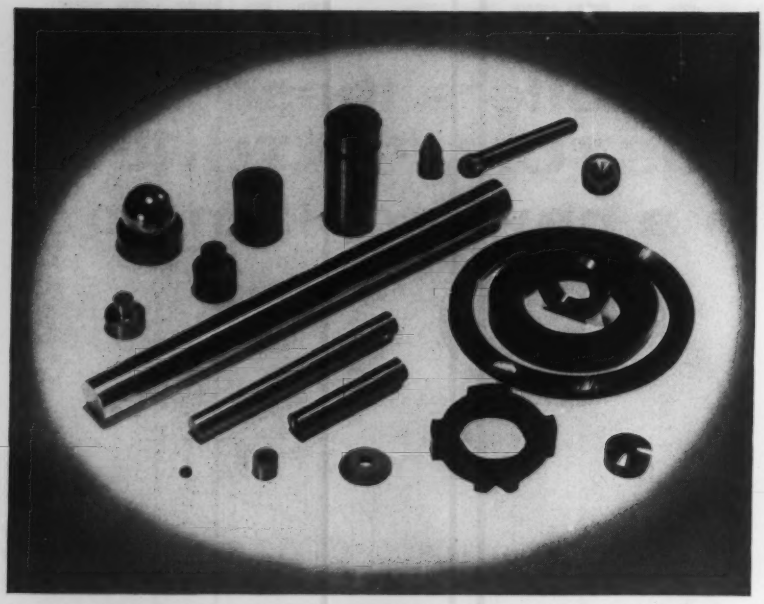
Please send: ☐ Complete details of Model RBC-2407 Servo Motors
☐ Information on other H-C Instrumentation Motors

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

Circle 509 on Page 19



Kennametal can be supplied as standard rectangular blanks, discs, rods, tubes, flats, balls, rings . . . and can be extruded, pressed, machined or ground . . . to precise tolerances for specific requirements.

When other materials won't do ...KENNAMETAL* usually will

High hardness and strength; resistance to abrasion, corrosion and high temperatures set Kennametal hard carbide alloys apart from all other design materials.

- Kennametal has an extremely high YME . . . up to 94 million psi compared to steel's 30 million.
- Some grades of Kennametal have a density as high as 15.5 gms/cc . . . twice that of heat treated steel . . . while other grades stand up for days in boiling 5% HNO_3 and 5% H_2SO_4.
- Kennametal is extremely hard . . . up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures as high as 2200°F.

Very broad applications have been found for these remarkable characteristics: long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical component parts are being made from Kennametal.

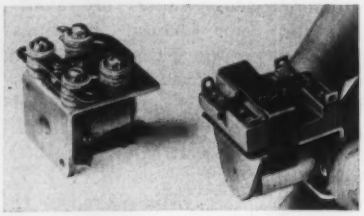
Pushing design frontiers ahead means forcing back the barriers of wear, pressures and temperatures. As man's imagination continues to develop ideas, new problems are encountered . . . for which Kennametal often has the answer. For example, here's how a pump manufacturer recently used Kennametal: problem—to obtain a large pumping capacity from a small pump . . . without increasing pump size. Solution—use Kennametal for critical operating parts to permit faster pump speeds and higher pressures. A simple answer, but made possible only by the great wear- and corrosion-resistant characteristics of Kennametal.

Perhaps Kennametal can solve one of your problems. If you'd like more information, just write Department MD, KENNAMETAL INC., Latrobe, Pennsylvania.

*Trademark

5780

INDUSTRY AND KENNAMETAL ...Partners in Progress



a one-piece phenolic molding. Molded phenolic parts provide greater thermal stability and rigidity to new relay. Silver contact assemblies are riveted to molded panel. Two-pole relay is rated for 2 amp resistive at 26.5 v dc or 115 v ac. As a single-pole, single-throw unit, it operates on power as low as 200 mw; as a double-pole, double-throw relay, it is actuated by 400 mw. Coils are also available for operation to 230 v ac, 60 cps. **Allied Control Co. Inc.**, 2 East End Ave., New York 21, N. Y. D

Circle 651 on Page 19

Simulated Plated Finish

for use over bright nickel plate

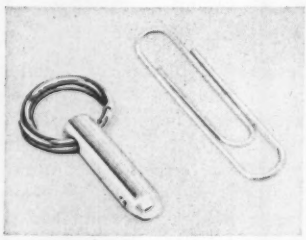
Platelustre finish is available to simulate brass, gold, copper, bronze, and other finishes over bright nickel plate. It also provides a protective chemical coating. Finish is applied by standard spray or dip processes. **Maas & Waldstein Co. Inc.**, McCarter Highway, Newark, N. J. D

Circle 652 on Page 19

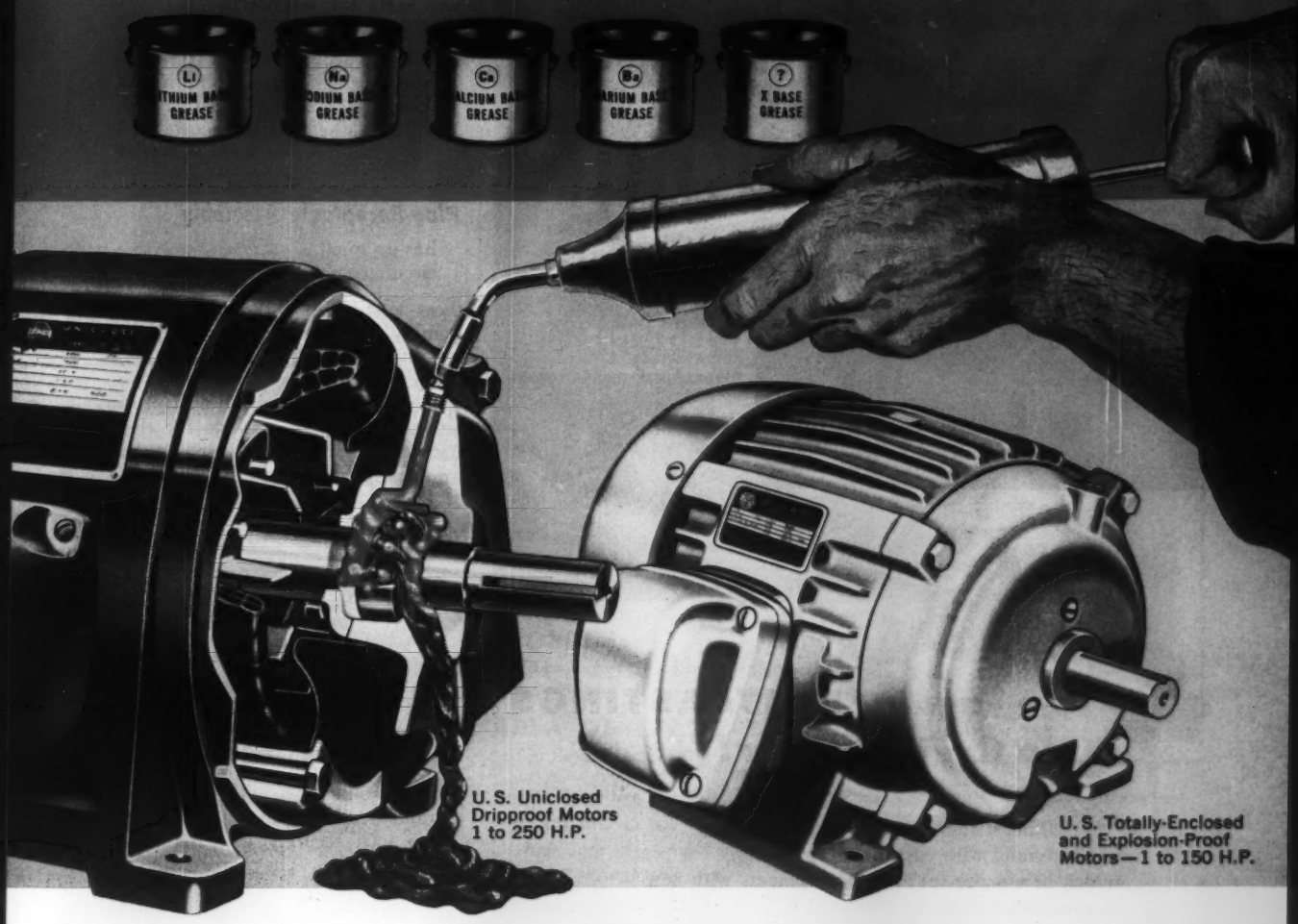
Quick-Release Pin

miniature unit is detent type

Miniature Faspin provides a fastening device that can be assembled or disassembled quickly and easily for use in miniature or subminiature assemblies and mechanical units. The quick-release detent pin is 3/16 in. in diam and is available



modern greases are not always compatible...

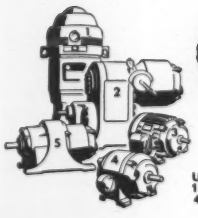

(Li) GREASE
(Na) GREASE
(Ca) GREASE
(Ba) GREASE
(?) X BASE GREASE
U. S. Uniclosed Dripproof Motors 1 to 250 H.P.
U. S. Totally-Enclosed and Explosion-Proof Motors—1 to 150 H.P.

...that's why it's important to assure

complete flush *with* Lubriflush*

***exclusive feature of U.S. MOTORS**

Today's greases have many different chemical bases – lithium, sodium, calcium, barium, and others. Some of these chemical bases react when mixed, making mixed grease unsuitable for bearing lubrication. That is why U.S. LUBRIFLUSH – an exclusive U.S. feature – is so important. With LUBRIFLUSH transverse lubrication, new grease *completely* flushes out the old. No mixing! New grease may be put in without bothering to determine whether it's basically compatible with the grease already in the motor. LUBRIFLUSH, moreover, assures proper lubrication for *longest bearing life!* Another good reason to specify: "U.S. ELECTRICAL MOTORS."



U.S. ELECTRICAL MOTORS INC.

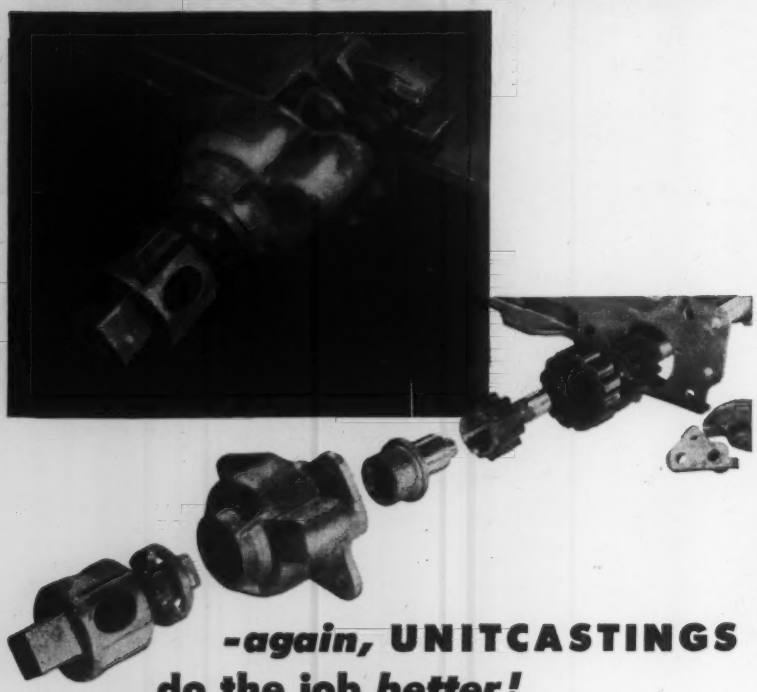
P. O. BOX 2058, LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

U.S. MAJOR MOTOR LINES INCLUDE:
1. Vertical Solid & Holloshaft, 2. Varidrive, 3. Totally-Enclosed, 4. Uniclosed, 5. Syncrogear. Also, many other special motors.

FREE COLOR BROCHURE
...for full information send for FREE Lubriflush Bulletin.

Circle 511 on Page 19

Progressive Foundry Engineering Develops Accurate Components . .



-again,* UNITCASTINGS do the job *better!

Unitcast foundry technicians, working hand-in-hand with customer's engineers, match new processes and developments with new steel casting demands.

The close tolerance requirements of this new horizontal gate mechanism proved a challenge. Designed around a new hypo-cyclic gear to reduce operating effort 80%, finished costs had to remain competitive. Each component was delivered to finished size with only touch up grinding necessary before assembly, and a high quality, durable product was marketed with the benefit of cast steel.

Unitcast offers similar service to help you with close tolerance, cost reducing problems. Write or call today for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

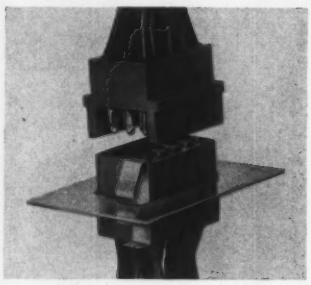
in all grip lengths. Steel construction offers high shear strength and surface hardness. **Aerofast**, P. O. Box 324, Wheaton, Ill. I

Circle 653 on Page 19

Plug-Receptacle Assembly

has up to 60 circuit combinations

Low-cost plug and receptacle assembly features positive polarity, up to 60 circuit combinations, simple assembly and mounting, and excellent electrical and physical properties. They are suitable for electronics, vending, appliances, communications, and other multiple-cir-



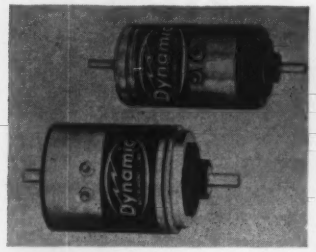
cuit installations. Terminals are automatically crimped to wires and snap lock securely into male and female units. They are easily removed with an ejector tool. Skirt on plug serves as both terminal protector and positive polarity. Snap clips permit quick, easy mounting and removal for panel installations. Bakelite units are small, compact, and durable. Unit for 15 circuits measures only 1-1/16 in. long and ¾ in. wide. Units are rated 6½ amp per connection, 125/250 v ac. **Molex Products Co.**, 9515 Southview Ave., Brookfield, Ill. I

Circle 654 on Page 19

Magnetic Clutches and Brakes

have extremely high torque ratings

Magnetic clutches and brakes are for use in servo and control systems, analog computers, and other precision instrumentation. Line encompasses nine models in five frame sizes. High torque ratings range from 6 oz-in. in size 5 to 224 oz-in. in size 18. Power consumption ranges from 2.5 to 5 w. Other features include low drag, long life,



low power consumption, high precision as to concentricity and size of shafts and pilot diameters, and fast response time. Units meet all applicable military environmental tests. **Dynamic Instrument Corp.**, 59 New York Ave., Westbury, L. I., N. Y. D

Circle 655 on Page 19

Pointer Knobs

minature units are for use with 1/8-in. shafts

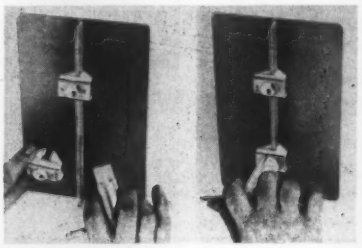
Offered in regular skirted and unskirted versions, Series 50 miniature pointer knobs are particularly suitable for use on miniature rotary switches. They are available for use with 1/8-in. shafts at present. The thermoplastic pointers are furnished in both mirror and nonreflective matte black finishes, with colors available on special order. **Industrial Apparatus Div., Raytheon Co.**, Waltham 54, Mass. B

Circle 656 on Page 19

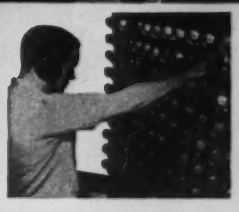
Locking Clamp

fits panels of any thickness

Designed for quick, easy assembly and disassembly of rooms and buildings of flanged-panel construction, Clamp-Lock is positive locking. It combines advantages of compact design with high closing pressure and tensile strength. Small size and ease of operation permit use in limited space. Lock is secured or opened instantly by a half-turn with 5/8-in. hex wrench. Fastener is available



UL AND CSA APPROVED



IN-PLANT TESTING . . . Shown is a test rack, where some of the more than 50 tests are given to *every* Hansen SYNCHRON motor *before* shipment to customers.

PROBLEM:

Jamming of gears at low temperature operation

AREA OF APPLICATION:

Oil field telemetering instruments

The Foxboro Company, a leading manufacturer of telemetering instruments, experienced continuous difficulties with synchronous motors operating metering and transmission equipment. Many such installations were in the field where extreme climatic conditions made reliability of the timing motors a prime requisite.

TESTING:

Over a 6-year period various timing motors, including Hansen SYNCHRON motors, were subjected to constant testing for dependability of operation. Tests included: continuous operation . . . as long as one and one-half years; gear noise check . . . initially, and after extended running; synchronous torque tests . . . motors had to deliver 0.9 in.-oz. of torque at 30 rpm; a 1500-volt shock to check breakdown rating between leads and cases to meet UL and CSA approval; starting ability . . . motors were packed in dry ice (—40°F) for one hour, then had to start within five minutes; three hours continuous running in dry ice . . . again at —40°F; five hours uninterrupted operation in an oven at 140°F.

If *you* must have performance in a synchronous motor . . . investigate Hansen SYNCHRON motors. Over 200 different types of output available. Hansen engineers will work with you to find a satisfactory solution to special application or design problems. For further information or assistance, contact the nearest Hansen representative or write direct to:

RESULT:

Only Hansen SYNCHRON timing motors **met all the exacting requirements!**

Hansen SYNCHRON timing motors were incorporated in all telemetering instruments produced, and singled out to replace motors on all applicable equipment now in use in the field. Foxboro is also reviewing over-all operations — to use Hansen SYNCHRON motors where possible on other instruments and controls.

h
HANSEN
MANUFACTURING
COMPANY, INC.
PRINCETON, INDIANA

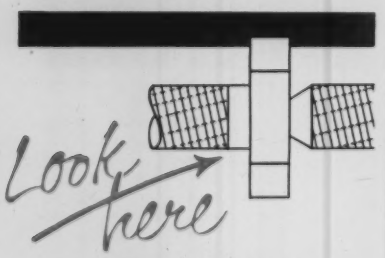
HANSEN REPRESENTATIVES: The Fromm Co., 5150 W. Madison St., Chicago, Ill.; Winslow Electric Co., New York, N.Y., Chester, Conn., Philadelphia, Pa., Cleveland, Ohio; Electric Motor Engineering, Inc., Los Angeles (WEbster 3-7591) and Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton, and Schenectady, N.Y.

Circle 513 on Page 19

LOOK
to Screwstick to improve profits

Profit Improvement Program

Look at the way screws-in-stick-form improve your profits by saving labor...eliminate fumbling and tedious handling of individual screws. Positive alignment between screw and threaded hole. Constant measured torque. One-handed operation. No special skills needed.



at self-tapping Screwstick that can contribute still more to your profit. You get the benefits of thread-cutting in small fastener ranges, plus all the advantages of Screwstick that save labor, time, money and improve your profits.

Buy here

The Biggest News in Fasteners comes from

American SCREW COMPANY

WILLIMANTIC, CONNECTICUT

CHICAGO, ILL. • DETROIT, MICH.

Circle 514 on Page 19

with jaws to fit panels of any thickness, and flexible fastening range of 0.025 in. provides clamping efficiency despite irregularities in material thickness. Unit is vibration-proof, has high closing pressure of 400 lb with no deflection, and high tensile strength of 700 lb with no permanent distortion. **Simmons Fastener Corp.**, North Broadway, Albany 1, N. Y. D

Circle 657 on Page 19

Electronic Connectors

miniature units withstand environmental extremes

Environmentally sealed miniature connectors are designed for dependable electrical and mechanical performance despite extreme temperature and vibration conditions. Developed for avionic equipment, Bantam connectors meet MIL-C-26482 (ASG) specifications and are completely interchangeable with

other miniature connectors. Copper-alloy, gold-plated, closed-entry contacts are embedded in moisture-proof resilient inserts protected by cadmium-plated shells of high-tensile-strength aluminum. Heavy spring tension for perfect interface sealing excludes moisture. Bayonet and double-stub coupling types are available. **H. H. Buggie Div., Burndy Corp.**, 726 Stanton St., Toledo, Ohio. G

Circle 658 on Page 19

Flat-Belt Pulleys

have cross-grooved, tire-tread surface

Cross-grooved surface of Neverslip flat-belt pulleys prevents entrapment of air between belt and pulley surface, providing low slippage, long belt life, and quiet operation without belt dressings. Pulleys are

TIPS AND TECHNIQUES

VOLUME I

DRAFTING AIDS

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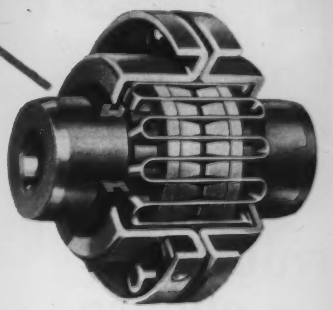
Photo shows portable pump unit connected to internal combustion engine by a Type F FALK Steelflex Coupling



How FALK STEELFLEX Couplings give your connected machinery Double Protection

FIRST: *They protect against shaft misalignment.* Some degree of shaft misalignment is unavoidable—and unless protective compensation is provided, additional loads are developed on shafts, bearings and other revolving elements. The result is excessive wear-and-tear—and often actual breakage....FALK Steelflex Couplings compensate for either angular or parallel misalignment—*or for the more serious condition involving both!* The exclusive Steelflex gridmember which joins the two hubs is not fastened to either hub; thus, either hub can shift in any direction without imposing a load on the other hub.

Yet, important as protection against shaft misalignment is to you, it is only one function of the *truly flexible* FALK Steelflex Coupling.

SECOND: *They protect against torque fluctuations* which create excess wear on connected machines and frequently induce destructive shaft misalignment. The exclusive FALK Steelflex grid-groove design cushions shock loads, dampens vibration, reduces impact loads as much as 30 per cent. You get this extra margin of protection that *can mean the difference between operating and breakdown!* You save on maintenance costs. And —you prolong the service life of your machines!...For complete information, ask your FALK Representative or Authorized Distributor. Or—**write direct for Bulletin 4100.**

FALK and STEELFLEX are Registered Trademarks

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

Representatives and Distributors in Most Principal Cities

Manufacturers of Quality Gear Drives and Flexible Shaft Couplings

Circle 516 on Page 19

Basic Type F FALK STEELFLEX COUPLING fills the needs of 90% of industrial applications

This cutaway view shows the exclusive Steelflex design which provides *torsional resilience with the strength of steel.* This torsional resilience spreads peak or shock loads over a relatively long increment of time, thus *greatly reducing stresses* in connected machinery.

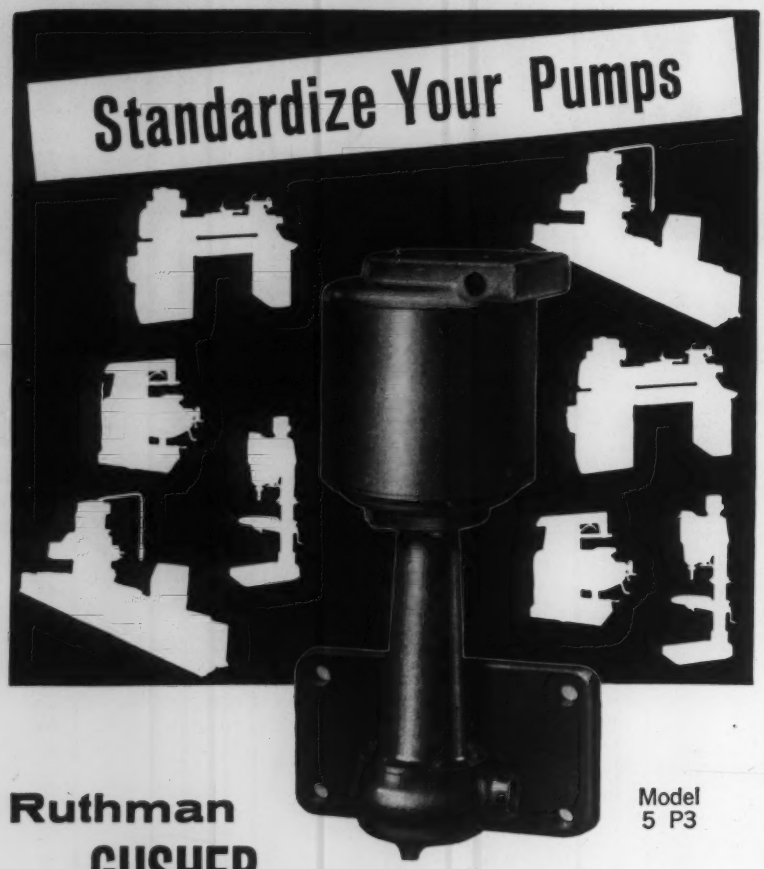
The versatile Type F Steelflex can be used horizontally or vertically, without modification or special parts. It is ideally suited to 9 out of 10 applications. For unusual applications involving overload conditions, extended shafts, brakes, etc., standard designs of dual-purpose Steelflex couplings are available.

For most applications, you can give your machines the extra protection afforded by FALK Steelflex Couplings at no extra cost!

FALK

...a good name in industry

Standardize Your Pumps



Ruthman

Model 5 P3

GUSHER COOLANT PUMPS

Give you PRECISION at a PRICE

Yes, Ruthman Gusher Coolant Pumps are precision built of the very finest materials, yet their initial price is moderate, maintenance cost practically nothing. It will pay you to standardize the pumping on all your metal cutting machinery with Ruthman Gusher Coolant Pumps.

Model 11025

Model 5 P3

FROM THE SMALLEST TO THE LARGEST,
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THERE'S A GUSHER FOR EVERY NEED

You'll find a full range of coolant pumps—from 1/30 to 7½ HP. Write and tell us what you need, we'll be glad to quote to your specifications—Better still call us at MA 1-5462.

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- COOLANT PUMPS
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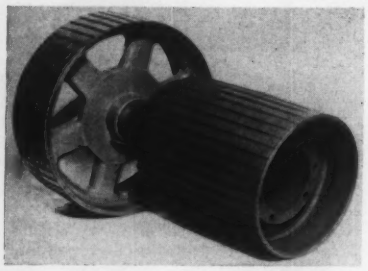
1811 Reading Road **Cincinnati, Ohio**



particularly adaptable to short center distances, and to use where intermittent machine loads are encountered. Sizes range from 3½ to 16 in. diam in widths to 12 in. to fit standard QD hubs. Fixed-bore types are also available. **Republic Engineering & Mfg. Co.**, 611 S. Snelling, St. Paul 16, Minn. J

Circle 659 on Page 19

V-Belt

has 40 per cent increase in horsepower rating

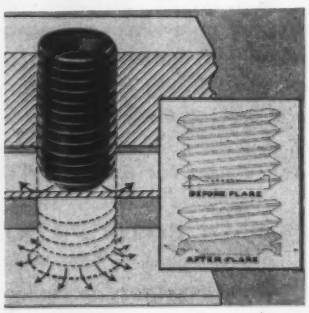
U. S. Royal V-belt has 40 per cent horsepower rating increase over previous belts at no increase in price. Cords of each belt are normalized and impregnated with latex in every fiber. They are built into belt under tension to insure that each cord operates uniformly. Fewer belts are necessary, and narrower sheaves are possible. V-belts are available in all stock transmission widths and lengths. **United States Rubber Co.**, 1230 Avenue of the Americas, New York 20, N. Y. C

Circle 660 on Page 19

Set Screw

has excellent retention

Point of Flare-Lok set screw is formed to flare out when tightened against bearing surface. Screw, once flared, becomes a tightening or adjusting screw. It does not



Do you need a small switch with a high current-carrying capacity? ...*Acro offers a 10 Amp Miniature and Sub-Miniature Switch.*

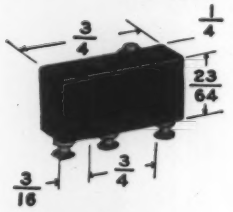
When space, or lack of it, is a stumbling block in your product, Acro miniature and sub-miniature switches can provide a quick solution to your problem.

For Acro miniature and sub-miniature switches carry loads from 3 to 10 amps!

With Acro Miniature and Sub-miniature switches you get big switch performance, long mechanical life (many millions of actuations on most types), and excellent environment characteristics—resistance to extreme temperature and vibration.

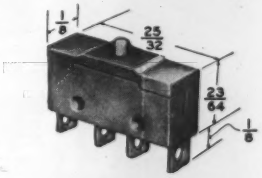
Acro miniature switches are also easily ganged for muti-pole application, and are available with very light operating force.

Acro Offers the Biggest Line of Little Switches



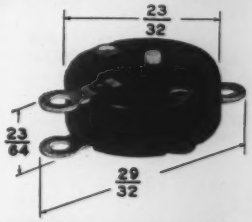
MODEL Z
(Sub-miniature)

High current-carrying capacity, long mechanical life. Designed for AC or DC applications. Available with roller leaf, or straight leaf, overtravel, and manual pushbutton, and toggle actuator. RATINGS: 5 Amp. 120/240 VAC; 30 VDC



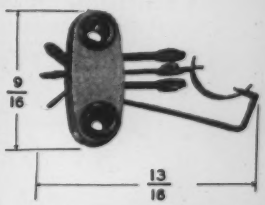
MODEL SM
(Sub-miniature)

Up to four times the capacity of other switches, all packed in an assembly that's less than one inch long! Approved by UL for 10 amps, 125-250 volts AC, and 10 amps, 28 volts DC. Double circuit terminals are standard on both normally open and normally closed contacts.



MODEL QD 1000
(Sub-miniature)

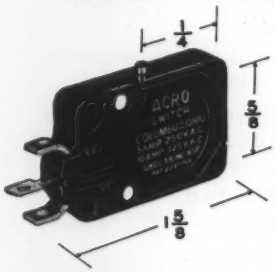
Low-cost precision switch, smaller than a dime. 10 amp capacity, works on a very light operating force. Available with disconnect terminals, panel mount, overtravel plunger also provided.



MODEL M-OM
(Sub-miniature)

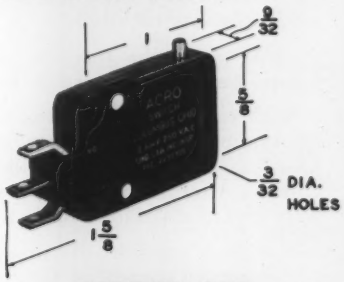
Here's a real sub-miniature switch — extremely small in size, with an unusual configuration that makes it a real space-saver. Carries a 3 amp load at 125 VAC. Can also be ganged for multi-pole circuitry.

Acro's Miniature Switches



MODEL M

A giant in capacity — a Tom-thumb in appearance. Carries full 10 amps, mechanical and electrical life measured in millions of actuations. Easily ganged for multi-pole circuitry, wide variety of external actuators available.



MODEL CM

Can be actuated by extremely light operating pressures, as low as 20 gms. Can be ganged for multi-pole requirements. Ideal for coin-operated devices or timers. Unlimited variety of actuators available. Rated at 3 amp, 125 VAC.

● No matter what your switching problem — from the miniature and sub-miniature switches shown here — to rugged giants that carry he-man loads — Acro is the source for a quick solution to your problem. Take advantage of Acro's free engineering service. Just write — telling us what you want a switch to do, where it has to fit — and how — and we'll get right to work on it for you. No obligation, of course.

OFFICES IN PRINCIPAL CITIES

Manufacturers of a complete line of load-tested precision snap-switches and relays

RELAYS ACRO SWITCHES

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MATCHED-TO-THE-JOB PERFORMANCE
assured by
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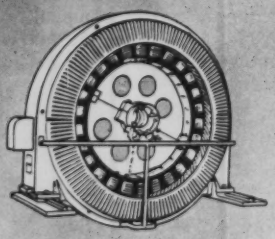
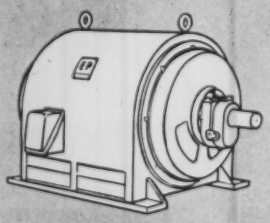
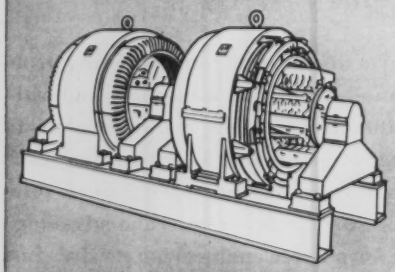


SYNCHRONOUS MOTORS
20-5000 HP
ASK FOR BULLETIN 43-205



INDUCTION MOTORS
60-1750 HP
ASK FOR BULLETIN 37-200



MOTOR-GENERATORS
¾-1500 KW
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also
ELECTROLYTIC POWER SUPPLIES
CONTINUOUS A-C and D-C POWER SYSTEMS
GENERAL-PURPOSE MOTOR-GENERATORS
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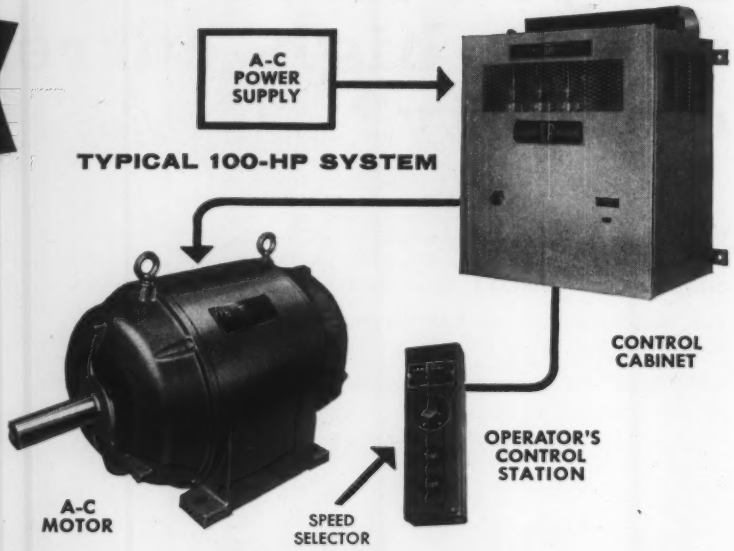


VAR EP ACK

THE ALL A-C ADJUSTABLE-SPEED DRIVE

VarEPack is today's answer to adjustable-speed requirements. It operates from alternating current, eliminating the need for costly and cumbersome current-conversion equipment. It connects directly to the load. No complicated belts or clutches are required.

VarEPack is the simplest, smallest, lightest and most compact adjustable-speed drive available.

With VarEPack, speeds can be selected or changed while the equipment is idle or while in operation. Changing speeds is done either manually or automatically by remote control. After the desired speed is selected, it remains constant regardless of load fluctuations or temperature changes.

VarEPack provides the smoothest starting and stopping . . . finger-tip control of acceleration and deceleration . . . fast, positive reversing . . . an infinite range of stepless speeds . . . and jogging, inching and creeping. For complete details . . .

ASK FOR BULLETIN 60-200

Sales and Service Representatives in All Principal Cities

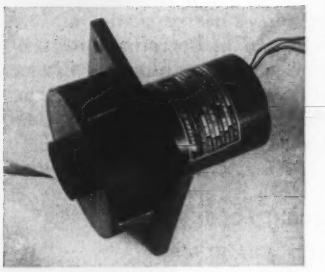
ELECTRIC PRODUCTS COMPANY
1725 CLARKSTONE ROAD CLEVELAND 12, OHIO
EP

continue to flare with successive tightenings, but retains compressed position, giving it exceptional point gripping power. Screw can be removed at any time when necessary without damaging mating thread. It is particularly useful for tools, machinery, or components that are subject to vibration. Screw is available in most metals in hex, slabbed, or slotted head. **Set Screw & Mfg. Co.**, Bartlett, Ill. I

Circle 661 on Page 19

Miniature Siren

is less than 2 in. in diam



Miniaturized siren is suitable for missile application or other installations requiring a miniaturized warning device. Less than 2 in. in diam, unit produces a tone of 1100 cps at 80 db at 11,000 rpm. It is powered by a 115-v ac, 400-cycle motor. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 662 on Page 19

Two-Volume Pump

requires single pressure setting

Two-volume pump prevents excessive heat generation and wasted horsepower by automatically maintaining system pressure with a small-volume pump while a fixed differential between relief-valve setting and unloading valve allows return of large-volume pump capacity to reservoir at negligible pressure. Unit requires only a single pressure setting for both unloading and maximum pressure. Unloading response is three times faster than that of previous two-adjustment models. Pumps are recommended for 1000 psi at 1200 rpm in small-volume operation and up to 750

Be sure the TEFLON* you buy has the Qualities you need

Processing can radically change Teflon properties

Take flex life as an example. The Teflon sheet illustrated was quenched to 50% crystallinity, resulting in an excellent flex life of 60,000 cycles. However, through lack of process control, it might have been cooled more slowly, giving a 56% crystallinity and a flex life of 40,000 cycles . . . A LOSS OF 20,000 CYCLES OF FLEX LIFE!

You can be sure of proper processing by specifying Teflon stocks made by Garlock's Plastics Division, the United States Gasket Company. U.S.G.'s years of experience with fluorocarbon resins guarantees you the right properties every time. This, plus assurance of fast delivery anywhere, makes Garlock your prime source of Teflon sheet, rod, tape, tubing, bars, cylinders. Find out more by calling one of Garlock Packing Company's 26 sales offices and warehouses throughout the U.S. and Canada.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

*DuPont Trademark for TFE Fluorocarbon Resin

United States Gasket

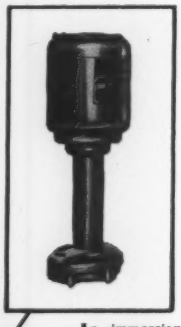
Plastics Division of GARLOCK

Circle 520 on Page 19

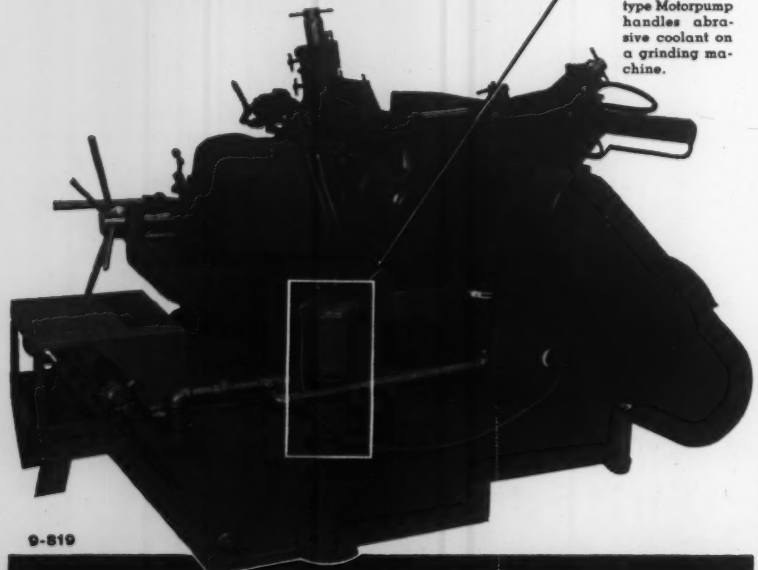
get the
design advantages of
MOTOR PUMP
versatility...

On many of today's machine tools and other equipment where liquid movement is important, you'll see dependable I-R Motorpumps. Designers know that when they specify Ingersoll-Rand Motorpumps they are getting modern, efficient design that pays off with long, lower cost operation.

Motorpumps are designed in a wide variety of types and sizes to meet your exact requirements. Why not get complete information on Ingersoll-Rand Motorpumps from a thoroughly trained pump specialist. Call your nearest I-R branch office or write direct.

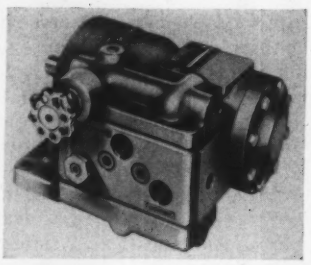


An immersion-type Motorpump handles abrasive coolant on a grinding machine.



9-819

Ingersoll-Rand / 11 Broadway, New York 4, N.Y.



psi at 1200 rpm in larger-volume operation. Two pump groups are provided. One has 18 combinations of small-pump cartridges with capacities of 4 to 21.4 gpm at operating pressure for small-volume operation. The other, with 30 combinations of small and large-pump cartridges, has capacities of 14.7 to 45.2 gpm at operating pressure for large-volume operation. Choice of foot or flange mountings is available. **Vickers Inc., Div., Sperry-Rand Corp.**, Detroit 32, Mich. H

Circle 663 on Page 19

Lacing Tapes

for wire harnessing are flat braided

Two flat-braided lacing tapes of Dacron and nylon have been developed for wire harnessing. Both tapes offer excellent dimensional stability and good heat resistance. Shrinkage per 1 F rise is 0.002 per cent with Dacron and 0.004 per cent with nylon, assuring minimum harness distortion. The Ben-Har tapes are completely pliable, have excellent knottability, and are easy to handle without irritating skin. They are furnished in natural off-white color in 250 and 500-yd spools or ¼-lb tubes. Five tape widths from 3/64 to ¼ in. are available. Tapes are also braided from Teflon-coated glass-fiber yarn. Coating eliminates abrasive action and gives

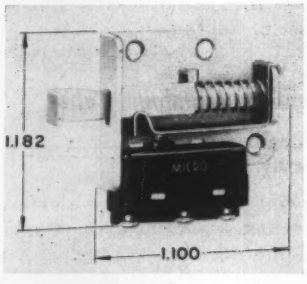
knottable surface. Both materials are flameproof, chemical-resistant, and nonabsorbent. There is no shrinkage on exposure to heat. **Bentley, Harris Mfg. Co.**, Conshohocken, Pa. E

Circle 664 on Page 19

Subminiature Switch

door interlock unit is for electronic cabinets

Tiny switch, designated 17AC1-T, is a door interlock unit designed for use on high-voltage cabinets and radio, radar, sonar, x-ray, and other electronic cabinets. Switch, which measures 1.182 x 1.5 x 0.35 in., automatically cuts off power when cabinet service door is opened. When plunger is pulled to maintained-contact position, it is pos-



sible to check circuits with power on. Plunger automatically returns to normal-operation position when door is closed. Total travel of plunger is approximately 5/32 in. in either direction. High-temperature, snap-action basic switch has SPDT contact arrangement. Electrical rating for 125 or 250 v ac is 5 amp. At 30 v dc, inductive rating is 3 amp at sea level and 2.5 amp at 50,000 ft. Resistive load is 5 amp. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

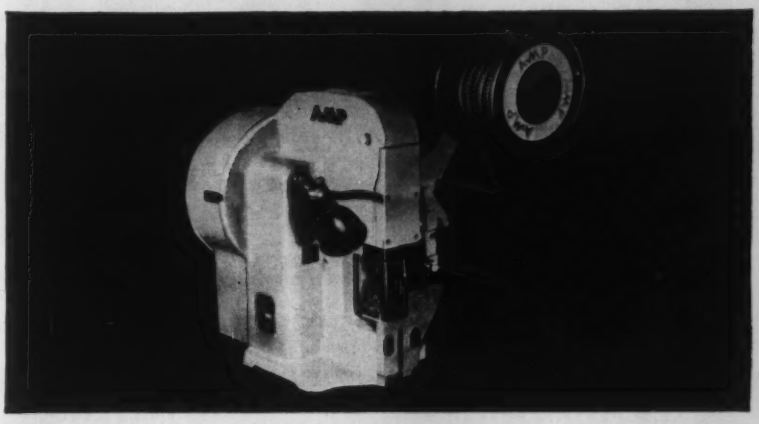
Circle 665 on Page 19

Adjustable-Speed Drive

has two slewing speeds

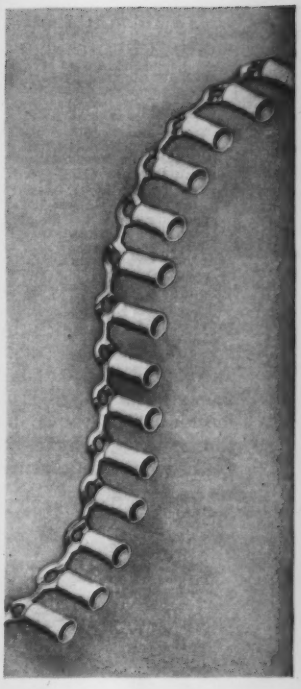
New model of Servotran is available for applications requiring an infinitely adjustable speed drive with vernier dial for precision speed setting, plus two additional high slewing speeds. With solenoid control switch in neutral position, ten-turn vernier dial can be set so output shaft runs at any speed from zero to

With the A-MP Termination Technique



EXPERIENCE

is the best feature



All the unusual features of the A-MP tool-and-terminal method which have created AMP's outstanding reputation are a result of one major feature: experience or "know how".

This experience is unmatched by any other organization in the world. The proof of it is in AMP's electrical circuit terminations, that is, a fine A-MP terminal crimped precisely and uniformly to your circuitry leads. A-MP "know-how" also means the lowest total installed cost—no extra parts, no multi-step assembly operations . . . just an A-MP tool and a supply of A-MP terminals.

Highest reliability without fuss or muss at the lowest total installed cost anywhere . . . experience says you can't beat such a combination.

Why not write for more information today on your particular circuitry termination requirements.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Circle 522 on Page 19

These small

MORGANITE

CARBON-GRAPHITE-WITH-METAL

CONTACTS

—can prevent costly equipment failures

FOR EXAMPLE, MORGANITE ELECTRICAL CONTACTS INSTALLED IN MAIN AND AUXILIARY CONTROLS WOULD HAVE PREVENTED THIS BRIDGE FAILURE

BRIDGE SLOWS SIX TRAINS

Traffic Waits for Stuck Drawbridge

Four passenger trains and two freight trains were delayed yesterday up to thirty-eight minutes when a main line drawbridge remained open through electrical failure.

The trouble, which began about 3:40 P.M., was not cleared up by 4:15. Normal service was maintained during the commuter rush period, according to a road spokesman. Inbound and

MORGANITE self-lubricating contacts and current collectors are non-welding. They improve electrical conductivity and reduce operating costs because of *minimum* maintenance requirements. MORGANITE electrical components, and self-lubricating mechanical carbons, have solved difficult design problems in thousands of commercial and military applications. For data on your specific requirements, call or write MORGANITE, today!

MEMO:

—to Designers/Engineers

Specify Morganite PY4 Seal Noses for Exceptional Service Life in Equipment Handling Grease, Searching Liquids, Corrosives, High Pressures and Temperatures.

Morganite

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In Canada: Morganite Carbon Products Ltd., Toronto

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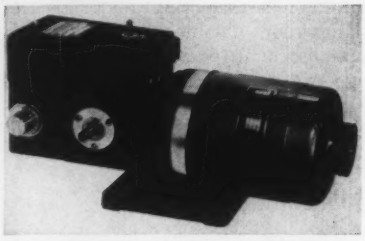


plus or minus full speed. Full speed forward or reverse is accomplished by moving solenoid control switch right or left, without disturbing vernier-dial setting. Easily accessible terminal board permits wiring for remote location of slewing switch. Slewing speeds can be changed by making an internal screwdriver adjustment. Model is available with motors to ¼ hp, 115 v, 60 cycle. **Humphrey Products Div., Humphrey Inc.**, 2805 Canon St., San Diego 6, Calif. L

Circle 666 on Page 19

Seamless Aluminum Tube

is light, strong, and easily handled

General-purpose seamless aluminum tube has applications in plumbing and heating trades, appliances, refrigeration and automotive work, and in similar industrial uses where a light, strong, easily handled tube is needed. Tube is made from 3003-0 aluminum alloy in soft temper. It flares easily by either manual or mechanical means, and uncoils easily for cutting or straightening. Sizes range from ⅛-in. OD with wall thickness of 0.025 in. and safe bursting pressure of 1066 psi, to ¾-in. OD with wall thickness of 0.049 in. and bursting pressure of 348 psi. **Chase Brass & Copper Co.**, Waterbury 20, Conn. B

Circle 667 on Page 19

Electrical Shielding Tape

eliminates crosstalk in intercommunications wire

Electrical shielding tape, called Metalshield, virtually eliminates intercommunications crosstalk resulting from wire inductance. Material is also over 50 per cent smaller, 30 per cent lighter, and easier to apply than other shielding materials. Metalshield can be applied in a solid wrap, directing all induced

WEATHERHEAD

offers one source for all tube fitting needs... a complete line of flared, flareless or pipe...

TUBE FITTINGS of BRASS, CARBON or STAINLESS STEEL

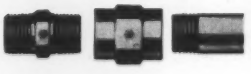
BRASS FITTINGS

S.A.E. 45° FLARE
USED with copper, brass, aluminum, steel and plastic tubing. PRESSURE RATINGS up to 5000 p.s.i. **Sizes: ⅛" to ¾".** Also available in 37° heavy pattern brass. Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.

COMPRESSION
USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.

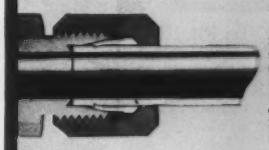
SELF-ALIGN®
No flaring, soldering, welding—insert tube and tighten nut. USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".**

INVERTED FLARE
USED with copper, brass, aluminum, steel, Bundyweld and plastic tubing. PRESSURE RATINGS up to 3000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L. Meets specs of S.A.E. Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes for instruments and control piping.

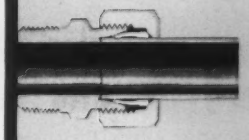


PIPE
USED with brass or steel pipe. PRESSURE RATING: up to 5000 p.s.i. **Sizes: to 2".** Meets specifications of S.A.E. TPHL Fittings Committee.

FORGED STEEL FITTINGS



"7000" SERIES ERMETO®
U.L. listed. Meets J.I.C. standards. S.A.E. approved "O" Ring boss design. Dryseal pipe thread. Needs no flaring. Available in either carbon or stainless steel. Carbon steel fittings have "Weathercoat" or cadmium-plate finish. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Ranges—⅛" through 2".**

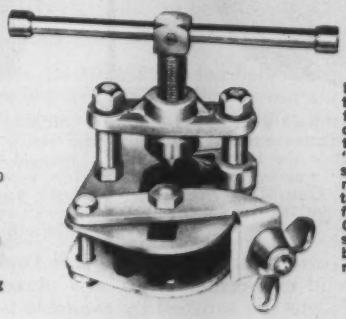


"8000" SERIES ERMETO®
Listed by U.L. for use with hazardous liquids, fuel equipment, refrigeration and gas; meets specs of S.A.E. and J.I.C. hydraulic tube fitting standards. Supplied as standard in cadmium-plated carbon steel and in stainless steel. Requires no flaring. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Range—⅛" through 2".**

FLARE-TWIN—(2-pc. or 3-pc.)
37° FLARE STEEL TUBE FITTINGS
Listed by U.L. S.A.E. and J.I.C. approved. Used with J.I.C. and other soft steel tubing; also with copper, aluminum, and fully annealed stainless steel tubing. Meets S.A.E. standards for straight thread boss mounting. PRESSURE RATINGS up to 10,000 p.s.i. **Sizes: ⅛" through 2".**

FLARE-TWIN
Made in 3-piece and 2-piece assemblies. 2-piece type offers price advantage. "Weathercote" or cadmium-plate finish.

FAST! EASY! ACCURATE TUBE WORKING TOOLS



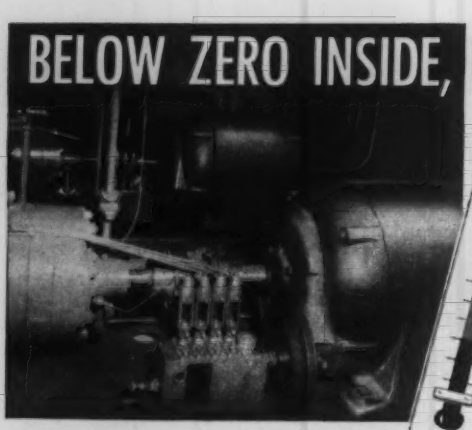
New rotary flaring tool for perfect tube flaring. Fast . . . one piece construction. Easier . . . "Dial - Matic" tube size selection. Accurate...tube stop automatically controls flaring diameter. Compact . . . easy to store. Available with burnishing attachment.

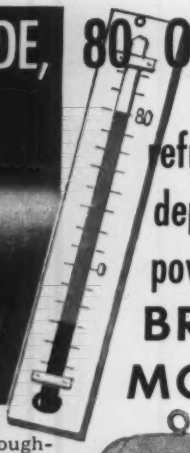
Spring-Type Bender | Mechanical Bender | Tube Cutter | Bar-Type Flaring | Tube Swaging | Automatic Flaring Rotary

THE WEATHERHEAD COMPANY

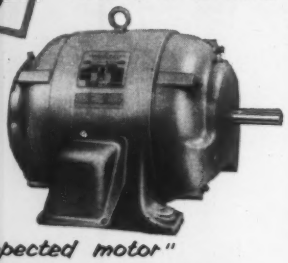
FORT WAYNE DIVISION • Dept. MD-7, 128 West Washington Blvd. Fort Wayne, Indiana

BELOW ZERO INSIDE, 80° OUTSIDE!





refrigeration dependably powered by BROOK MOTORS



Evans Packing Company, Dade City, Fla., uses Brook Motors for refrigeration throughout their plant—one of the finest in the industry. Three of seven Brook Motors are shown on vital refrigerant compressors used in freezing and storage of concentrated citrus juices—shut-downs cannot be tolerated—an ideal spot for Brook Motors. There are no finer motors built, yet they cost less than ordinary motors. Dealers and Service Centers everywhere. Send for literature.

SINCE 1904

BROOK MOTOR CORPORATION

"world's most respected motor"

BROOK MOTOR CORPORATION

3302 W. Peterson Ave., Chicago 45, Illinois

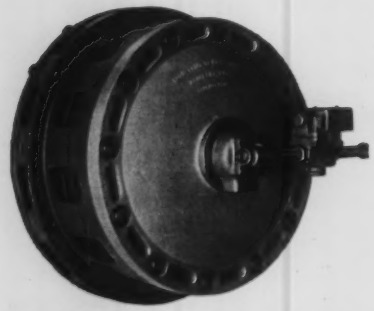
In Canada: Brook Electric Motors of Canada, Ltd. 250 University Ave., Toronto.

Factory Representatives, Warehouses, Dealers in Principal Cities.

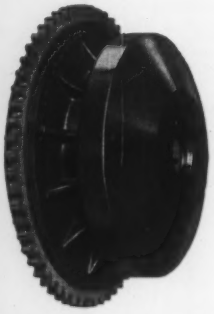
Circle 525 on Page 19

A Quality Line of Air-Operated Clutches

For General and Special Applications



This "LK" Clutch is engineered for high production. It never needs adjustment and combines the lowest inertia of driven parts with exceptionally high torque capacity. Complete range of sizes — 3,300 to 860,000 lb. in. torque ratings.



Our single and multiple disc Gear Tooth Clutches for general industrial use have low power losses, low upkeep, and long life. Air-engaged, spring-released — adaptable to remote control.

Our line of Superior Quality Clutches and Brakes includes also spring-loaded and over-center types, and clutches designed for operating conditions not satisfied by available types. Write us at Box 118, Waukesha, Wisconsin or Telephone LIberty 7-3359.

INDUSTRIAL CLUTCH CORP.

Waukesha Wisconsin

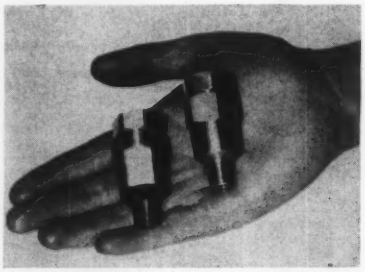
currents to a drain wire which can be soldered or bolted to a ground. Material is produced by laminating 0.00035-in. aluminum foil to 0.0005-in. Mylar, then slitting to desired widths. **Dobeckmun Co. Div., Dow Chemical Co.**, 3301 Monroe Ave., Cleveland 1, Ohio. G

Circle 668 on Page 19

Small Filter

filters particles as fine as 5 mu

Designed for use on small air-operated instruments, checking gages, and miniature valves, Model 1117-2 filters compressed air to prevent damage from sludge, rust, and dust. It measures $2\frac{1}{2}$ x $1\frac{1}{8}$ in. and weighs only 4 oz. Unit has $\frac{1}{4}$-in. MPT one end and $\frac{1}{4}$-in. FPT opposite. Filter cartridge filters particles as fine as 5 mu in size. It



is absorbent and traps and holds oily sludge. **Wilkerson Corp.**, 1646 West Girard, Englewood, Colo. K

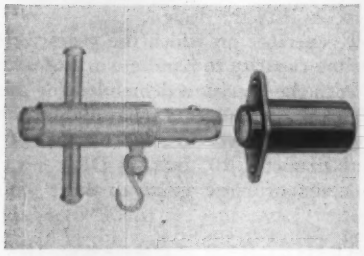
Circle 669 on Page 19

Pin and Receptacle

quick-release assembly is for flush-skin mounting

Ball-lok pin and receptacle assembly is a positive-locking, quick-release combination that eliminates accidental release from vibration or pull on attaching member. Release is accomplished by pushing pin-release

button and pulling pin in one motion. Mounted in skin surface, the permanent receptacle becomes a fast, reliable attaching point for hold-down straps, test equipment, or for use as a winching point. Receptacle and pins are available in three individual materials within same pin diameters for a complete range of shear strength values. Receptacles fit 3/16, 1/4, 5/16, and 3/8-in. diam standard G-series pins. Receptacles are manufactured for 1/8-in. skin thickness, with five



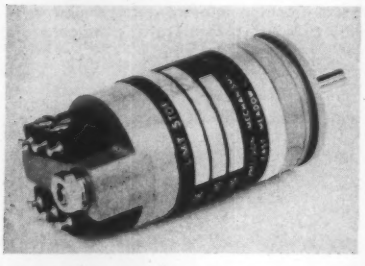
mounting-plate shapes for adaptation to application. Shims are supplied for skin variations. **D. W. Price Corp.**, 11161 W. Pico Blvd., Los Angeles 64, Calif. L

Circle 670 on Page 19

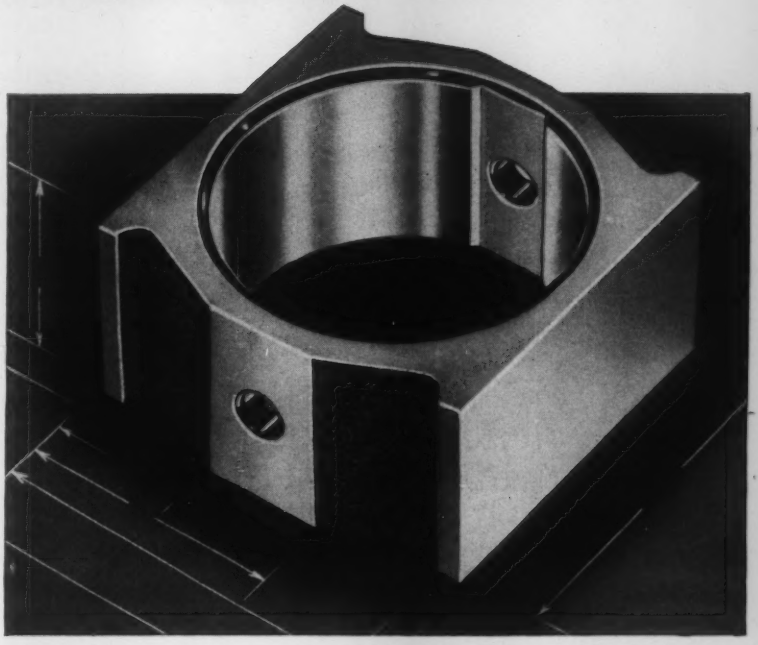
Limit Switch-Stop

adjustable unit is for servos and instruments

LS 302 limit switch-stop features a single exterior range-adjustment screw which permits rapid adjustment to any angular rotation from zero to 25 turns. Limit switches are actuated at either end of shaft travel just prior to contact with nonlocking limiting stops. Switch-stop, for use in servos and instruments, has diameter of 0.937 in. and length of 2 in. Shaft diameter is 0.125 in. Other features are torque capacity of 40 oz-in. at end stops, low operating torque, and low inertia. Construction, of corrosion-resistant steel and anodized



many difficult requirements...



We illustrate the cast bronze cam block for a hydraulic pump operating the hydraulic lift mechanism on an exceedingly well-known line of farm tractors.

The manufacturer of this equipment has very unusual specifications for this cam block. Its bore has a very fine finish specification. It also must be round and true to size within unusually close limits. In addition, it must be square to the face of the cam block within limits that ordinary methods of manufacture will not attain.

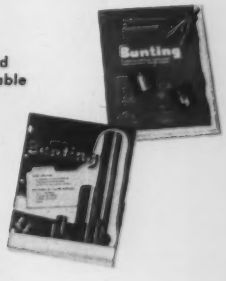
Bunting methods of manufacture result in a part which is completely to the customer's exacting specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered metal, or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.



Bunting®

The Bunting Brass and Bronze Company
Toledo 1, Ohio—EVergreen 2-3451
Branches in Principal Cities

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS. ALCOA® ALUMINUM BARS

Circle 527 on Page 19

Huge bearing for Nike-Zeus radar system incorporates Farrel® precision internal gears

Weighing 14,600 pounds, this bearing is designed to turn at 10 RPM during a minimum desired operating life of 10 years. 341-tooth integral drive gear will mesh with a pinion to rotate the radar system. Gear has an inside diameter of 137.600" and a 5" face. The data gear (not shown) has 1920 teeth and a 1". face.

The largest precision ball bearing ever fabricated—13'9" in diameter, with 88 four-inch balls—has recently been completed by the Kaydon Engineering Corp. Designed to carry a rotating dead weight of up to one million pounds, it will be used in the supporting pedestal of a Nike-Zeus radar system.

Drive and data gears were cut by Farrel to very close tolerances. These were made integral with the bearing to eliminate the accumulative errors inherent when a number of parts are pieced together, and to simplify the design.

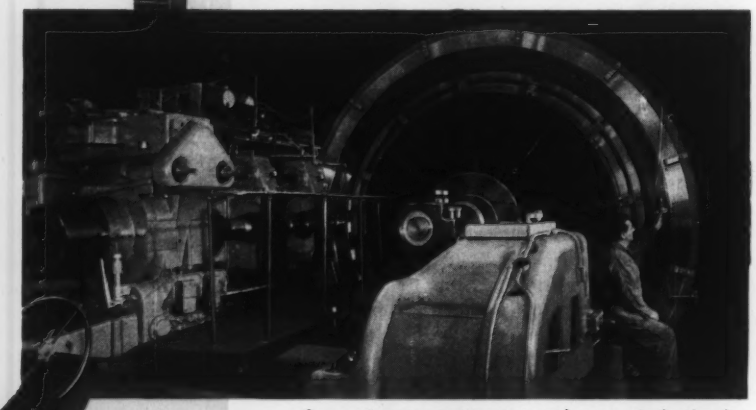
The Farrel generator on which the gears were cut combines the capacity to handle work of such proportions with the precision demanded for this application. Farrel internal gears are available with spur or single-helical teeth in sizes up to 23'0" external blank diameter, 20" face, ¾ DP.

Ask for details of large gears to meet your requirements.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia & Derby, Conn., Buffalo & Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Atlanta
European Office: Piazza della Republica 32, Milano, Italy

FARREL



Generating a precision internal gear, similar to the one supplied to Kaydon in a Farrel gear generator.

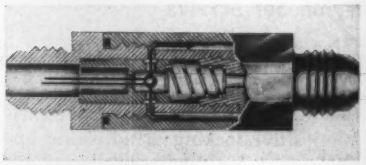
FB-1172

aluminum alloy, conforms to applicable sections of MIL-E-5400. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 671 on Page 19

Flow Regulator

for fuels and oils



Flow regulator provides a constant flow rate of 1.7 gpm, ±3 per cent, regardless of differential pressures from 10 to 2000 psi. In ⅜-in. line size, unit handles operating pressures to 3000 psi and proof pressures to 4500 psi. It operates in temperature range of −65 to +350 F. Valve is available in other line sizes to handle a variety of flow volumes. It can be modified for tight flow tolerances, other differential ranges, and temperatures to 700 F. **Aero Supply Mfg. Co. Inc.**, Corry, Pa. F

Circle 672 on Page 19

Wire-Wound Potentiometers

are three and ten-turn types

Line of metal three and ten-turn precision wire-wound potentiometers consists of eight new models, four ten-turn and four three-turn units. Anodized aluminum cases with 3/16-in. wall thickness provide dimensional stability. All models are available with diameters of ⅞, 1, 1-5/16, and 1-13/16 in. The multiple-turn units are constructed of nonhygroscopic materials and operate over temperature range of −55 to +150 C in relative humidity of

Circle 529 on page 19→

NEW

This is the ~~old~~ grind at

ALLEN

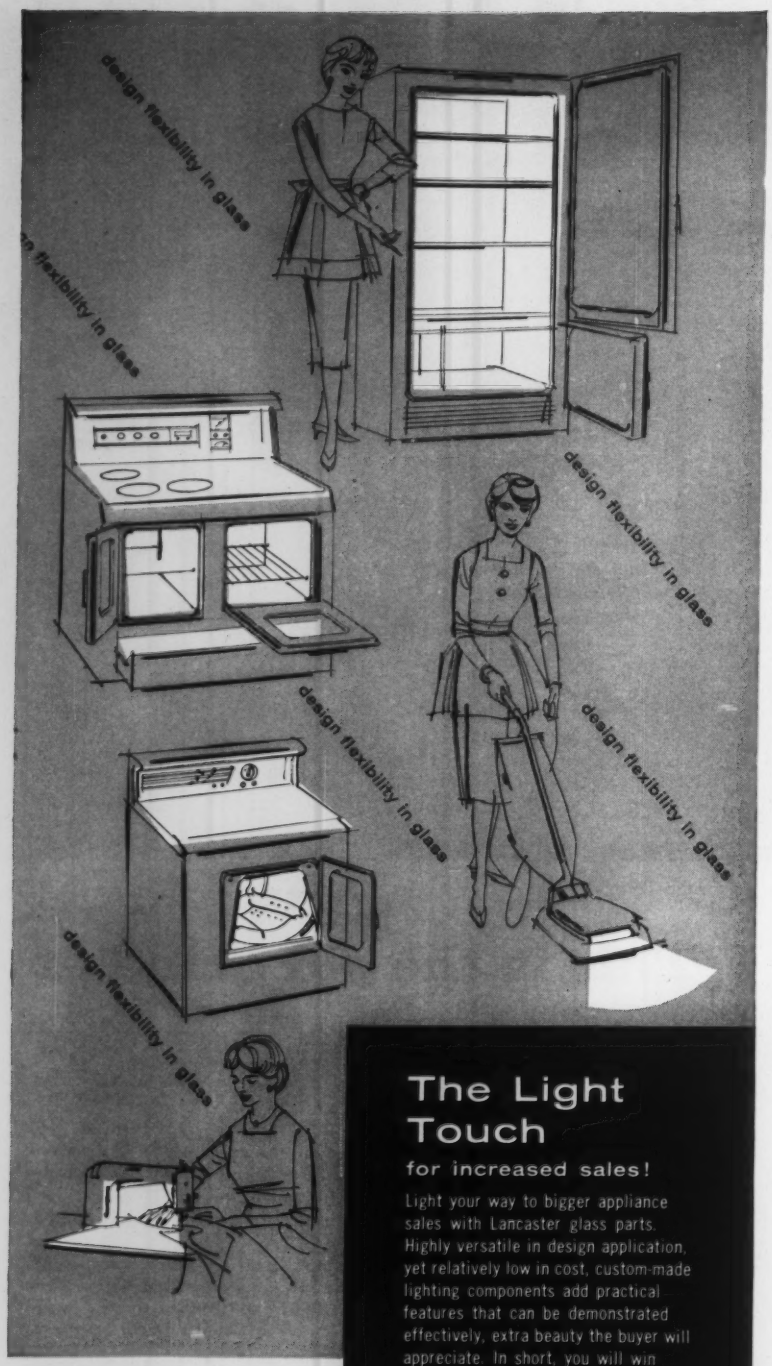
A quarter of a million square feet of space in the great new Allen plant is devoted to precision fasteners – and much of it houses batteries of the latest, high-speed automatic centerless grinding equipment. Here you see a close-up of the grinding section set up to produce dowel pins at the rate of one a second per machine.

Allen's vast new facilities assure constant standards of uniformity, accuracy, strength and fit, many of which are duplicated nowhere else. Now there's more reason than ever to make Allen *your* Buy-Word for socket screws, keys, pipe plugs and dowel pins.

Speaking of dowel pins – specify *Allen* for great strength where you need it most. Made of Allenoy steel, they're surface hardened to 62-64 Rockwell C. Core hardness 47-53. Case depth .010″ to .020″. Shear strength from 160,000 to 180,000 psi. Precision-ground to ±.0001″, with a mirror finish of 6 RMS max.

In stock at your Allen Distributor . . . in dias. from ⅛″ thru 1″ . . . lengths from ⅜″ thru 6″. Also in two standard oversizes – .0002″ for press fit, .001″ for repairs. For more details, ask your local Distributor, or write directly to the Allen Manufacturing Company, Hartford 1, Conn.

ALLEN HEAD HEX-SOCKET SCREWS


design flexibility in glass
design flexibility in glass
design flexibility in glass
design flexibility in glass
design flexibility in glass
design flexibility in glass

Lancaster®
glass and plastics
to brighten your product's future

The Light Touch
for increased sales!

Light your way to bigger appliance sales with Lancaster glass parts. Highly versatile in design application, yet relatively low in cost, custom-made lighting components add practical features that can be demonstrated effectively, extra beauty the buyer will appreciate. In short, you will win friends and influence prospects at the vital point-of-sale.
Our lighting engineers can help you create new product applications, assist you with special assembly, optical or engineering problems. Put this expert knowledge to work for you, write Lancaster Glass Corporation, Lancaster, Ohio, or call OLive 3-0311.

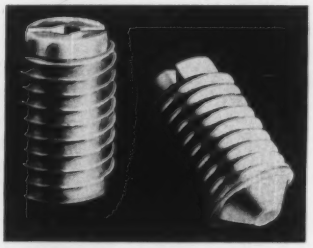
95 per cent. Resistance ranges are available to 400,000 ohms ±3 per cent, with special ranges to 1 million ohms. Units function to 20 g vibration from 55 to 2000 cps, withstand 30-g shock, and meet specifications to 30,000 ft. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 673 on Page 19

Nylon Set Screws

for positive-locking or adjusting applications

Low-cost nylon set screws, designed for positive locking or adjusting applications, are available in plain, oval, cone, flat, half-dog, and full-dog point types. Sizes range from No. 4-40 through 5/16-24 in stand-



ard lengths from 1/4 to 13/32 in. Hex socket or screwdriver slot driving recesses are available. **Richco Plastic Co.**, 4443 W. Fullerton Ave., Chicago, Ill. I

Circle 674 on Page 19

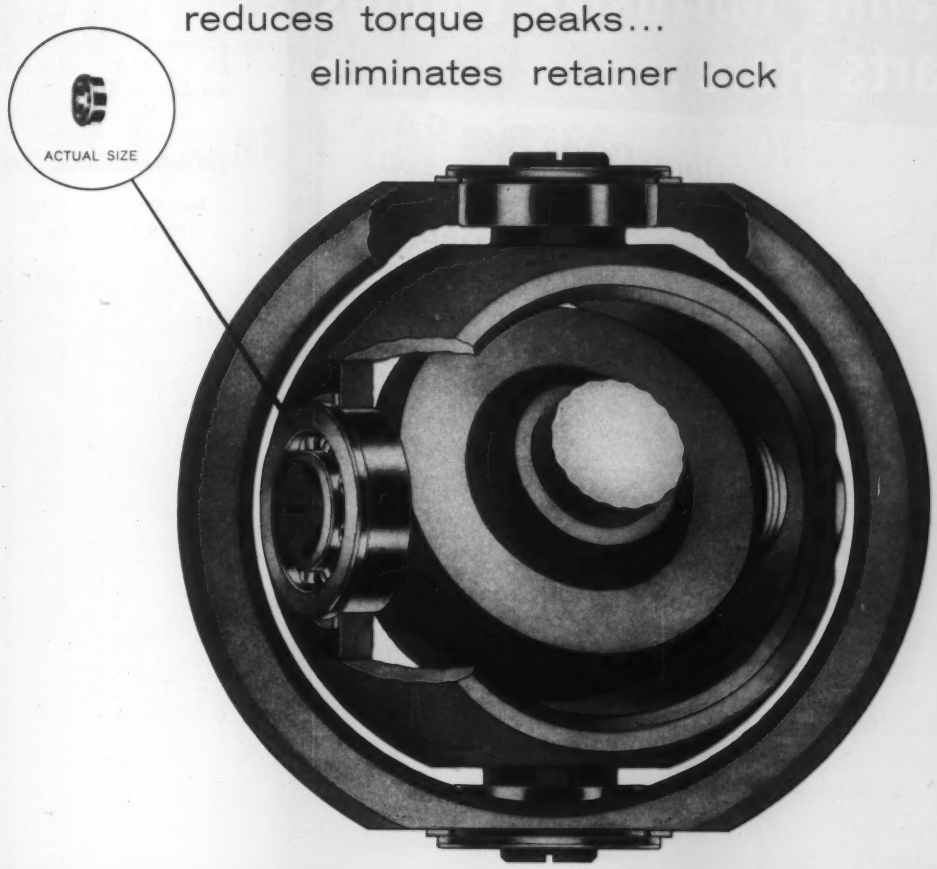
Self-Sticking Markers

identify small wires and components

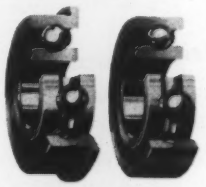
Small self-sticking markers for permanent or temporary identification of thin communications wire and tiny electronic components are made from 5-mil pressure-sensitive vinyl. Two black, easy-to-read numerical legends are on each 5/16 x 5/64-in. marker, and markers are mounted on dispenser card. Two ends of marker are stuck together around wire lead to form a flag. Printed identification can be seen from either side of wire after installation. Markers are oil and grease resistant, and withstand constant operating temperature of 180 F without curling or falling off. Numerals 0 through 25 and a series of consecutive numbers 0-99, plus consecutive numbers repeated, are offered from

Circle 530 on Page 19

BARDEN "W" retainer reduces torque peaks... eliminates retainer lock



Low-torque reliability for gyros, synchros and other torque-sensitive components



"W" retainer bearings are available flanged or unflanged, shielded or open, in sizes most in demand ⅝" O.D. and under. For complete technical information write for engineering data sheet W-1.

An instrument bearing that passes all normal torque tests can develop excessive torque peaks in operation. In gyro gimbals, synchros and similar applications the result is erratic component performance. To solve this reliability problem, Barden developed the "W" ball retainer.

Field tested and proved in actual operation, Barden "W" retainer bearings are specified for a growing number of torque-sensitive applications. • • • *In gimbals on the Sidewinder they contribute to the missile's reliability.* • • • *In attitude gyros they save one manufacturer $100 per unit by reducing costly teardown.*

Like other Barden advances in engineering and manufacturing, "W" retainers answer a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400°F)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
- Concentric rotation (to .00005" max. T.I.R.)

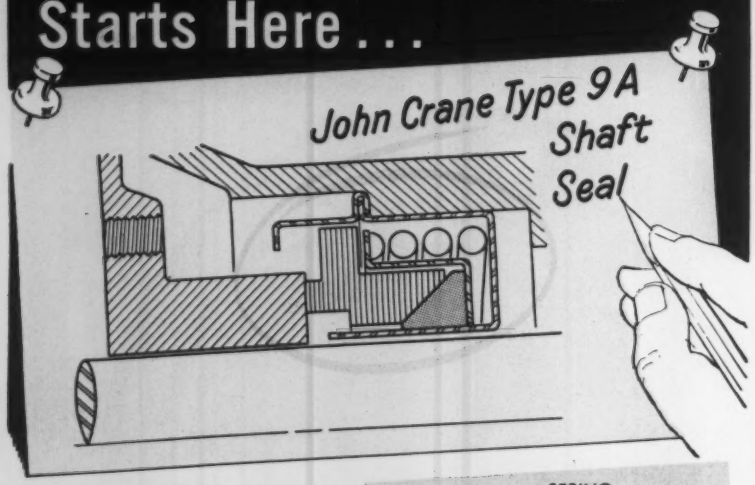
The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.

for reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 73 East Franklin St., Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California.

Circle 531 on Page 19

Sealing Corrosive Liquids Starts Here...

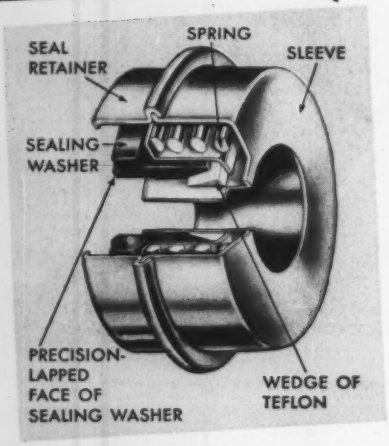


This cartridge-type shaft seal designed for the production line is engineered for:

(1) positive sealing of many industrial chemicals and solvents (note the Teflon* sealing wedge);

(2) leakproof handling of inflammables and toxics;

(3) operation over a wide temperature range from −120° to +500°F., pressures to 150 psi.



It offers the Original Equipment Manufacturers these important advantages:

(1) low unit cost through mass production;

(2) fast, one-piece installation through cartridge construction;

(3) equal efficiency on both low or high speed applications, because seal does not rotate with shaft.

The 9A Shaft Seal can be of stainless steel, monel, brass or other materials adapted to stamping and forming—depending on the service requirement.

Get full details. Request Bulletin S-205-3 from Crane Packing Co., 6425 Oakton Street, Morton Grove, Illinois *(Chicago Suburb)*.
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

**DuPont Trademark*

John Crane — MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

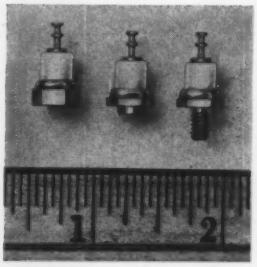
CRANE PACKING COMPANY
OFFICES IN ALL PRINCIPAL CITIES

stock. Special markers are available on special order. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 675 on Page 19

Teflon-Insulated Terminals

for use in severe humidity



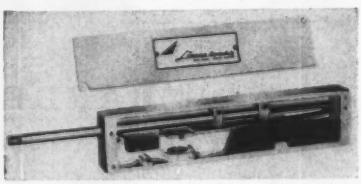
Teflon-insulated terminals, designated 1945, 1946, and 1947, have a double-turret-type solder terminal securely seated in Teflon. Mounting studs include external threaded, rivet type, and internal threaded. External threaded and rivet-type terminals are 9/16 in. high when mounted; internal threaded type is approximately 5/8 in. high. All three types are about 3/8 in. in diam. External threaded type is available with 1/4 or 3/8-in. shank; rivet type is available in six shank lengths for mounting on panels 1/32 to 1/8 in. thick. Internal threaded type is available with No. 6-32 or 4-40 thread. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass. B

Circle 676 on Page 19

Switching Units

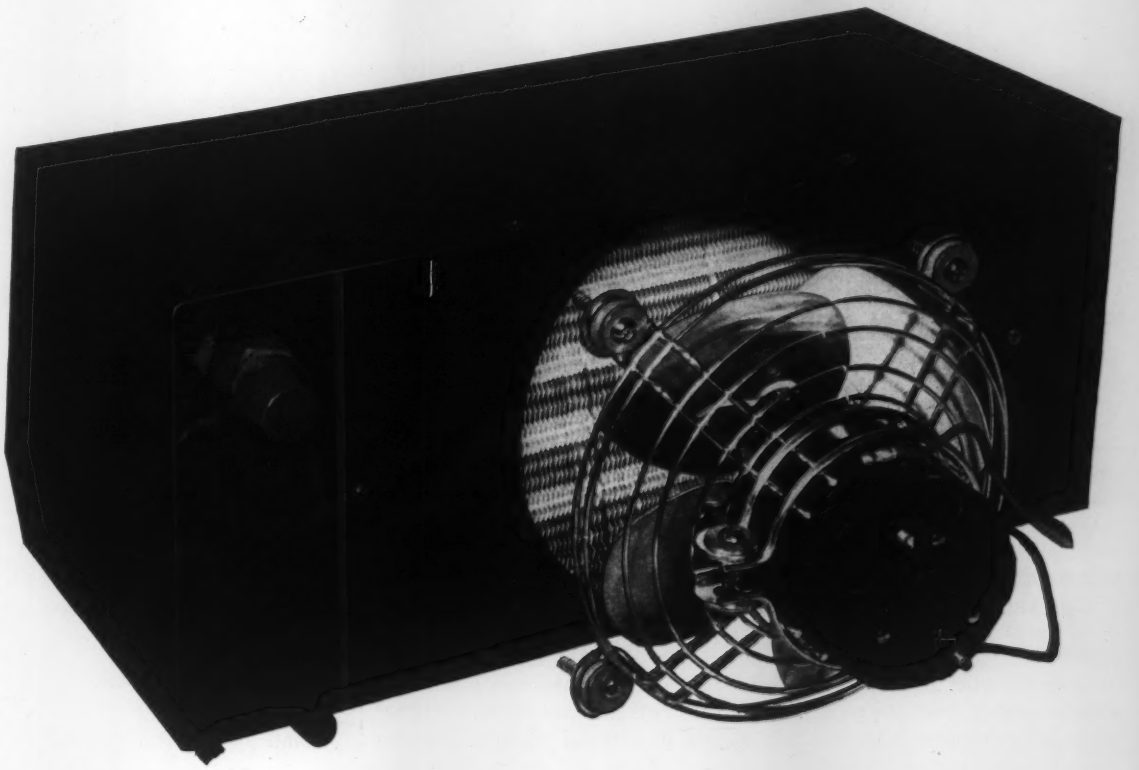
control linear machine movements

Packaged electromechanical units provide efficient electrical control of linear machine movements. Design provides self - contained units in which two 2-circuit, double-break, snap-action switches are operated by adjustable cams mounted on a rigid, heavy-wall sliding actuator tube

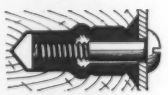


B.F.Goodrich

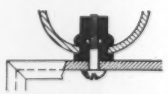
RIVNUTS® speed assembly of Frigette car air conditioner



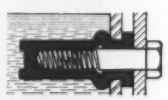
IN THIN SHEET METAL
B.F.Goodrich Rivnuts provide firm, accurate nutplates with clean threads. Eliminate pulling or tearing of thin metal. Can be installed after enameling!



IN WOOD – Splined Rivnuts give 6 clean threads for attachment, eliminate wood screws. Bulge formed by upsetting anchors Rivnut in wood. Splined shank prevents turning.



IN TUBING—In blind applications, B.F.Goodrich Rivnuts hold firmly and permanently because bulge in Rivnut conforms to curvature of the tube.



IN TANKS – Rivnuts with closed ends make a 100% liquid-tight seal. Rivnuts provide nutplates that are not loosened by shock or vibration.

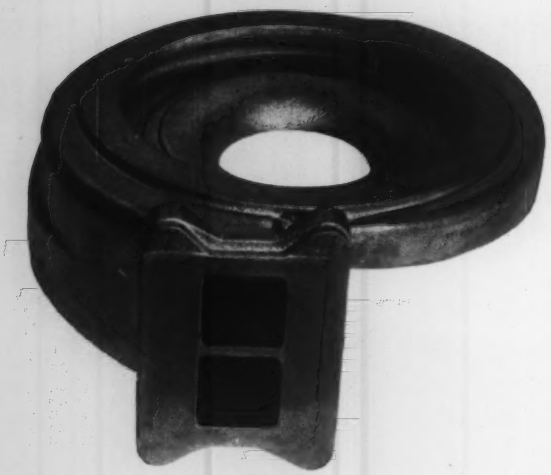
B.F.Goodrich Rivnuts have proved "the most complete answer" to a fastening problem at Frigiquip Corporation, manufacturers of Frigette automotive air conditioners. In more than 25,000 applications there has never been a failure.

The problem was to attach fan guards to evaporator cases as quickly and efficiently as possible – without welding. Fan guards had to be easily removable for servicing.

Solution? Simply punch four holes in the evaporator case and install the Rivnuts. Then fasten the fan guard to the Rivnuts with screws. Rivnuts form solid nutplates that stay put when service mechanics remove the fan guard.

B.F.Goodrich Rivnuts cut costs and assembly time in many jobs. (See examples at left) For help in solving your own tough fastening problems, call in *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-79, Akron, Ohio.*

B.F.Goodrich
aviation products



THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

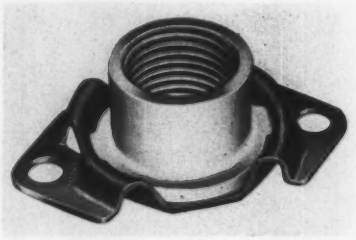
1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

coupled to an air cylinder or sliding machine member.Movement of cylinder operates switches at preset points, and controls machine members operated electrically through switches. Five sizes are available for stroke length requirements of 0-4, 0-8, 0-12, 0-18, and 0-24 in. **Linear Controls Co.**, 3400 Main St., Skokie, Ill. J

Circle 677 on Page 19

Lightweight Anchor Nut

for temperatures to 900 F



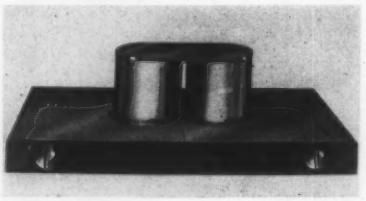
Two-lug, lightweight floating anchor nut is available in 1/2-20 thread size. Material is A-286 corrosion-resistant steel for temperatures to 900 F. **Nutt-Shel Co.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L

Circle 678 on Page 19

Thermoelectric Junction

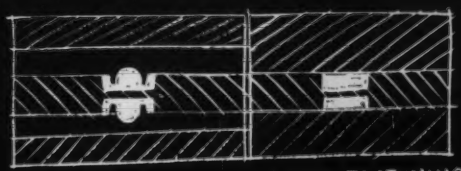
heats or cools a small thermal load

TA-11 thermoelectric junction is designed for applications where it is desired to maintain a temperature which is either above or below ambient. Unit can be used for cooling, heating, power generation, and dynamic heat transfer. It is especially suitable for control applications such as quartz crystal ovens, critical electrical circuits, and biological specimens. In normal room ambients, with input power of 2 w to the junction, it is possible to obtain a temperature difference in excess of 40 C. With no



Circle 534 on Page 19

LEAKS *CAN* BE STOPPED!

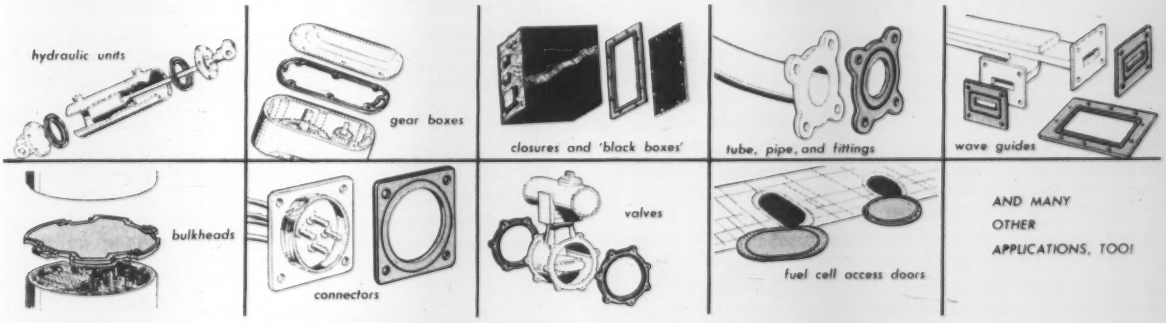


Controlled Confinement

Safe, sure sealing is vital in today's high performance machines, aircraft missiles, ground support equipment and processing equipment and *there* is a better way to seal them . . . GASK-O-SEALS.

The Gask-O-Seals shown here are static seals that can actually provide sealing that will *exceed* hermetic top specifications. Yet, they are mechanical, can be removed, and reused. *Controlled confinement* of the rubber makes them superior to other seals.

The "typical" applications shown are just a few of the ways Gask-O-Seals are being used. Practical, *truly* economical, no-leakage sealing. If you want to *seal* for *sure*, find out about Gask-O-Seals. Just drop us a line or use the reader service card.



Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

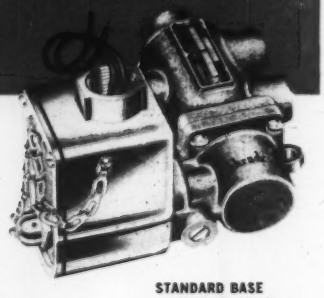
ALL THESE... *full lines from Schrader...*

AND NOW...

NEW JIC SOLENOID AIR VALVES

..... that meet and exceed JIC specifications

SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.



STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

Schrader's complete line of air valves allow you a freer hand in planning air circuits for your applications. Besides almost unlimited choice of size, style and actuation method, you get these extras in every Schrader valve you buy:

- All parts are designed for maximum air flow, longest service life; simplicity of replacement; interchangeability.
- Schrader Valves feature tough, practical design, precision construction, and are individually tested to full ratings.
- Performance has been proved by years of use in hundreds of plants. All Schrader Valves can operate with Schrader (JIC) Square End Cylinders perfectly.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

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476 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
a division of **SCOVILL**

QUALITY AIR CONTROL PRODUCTS

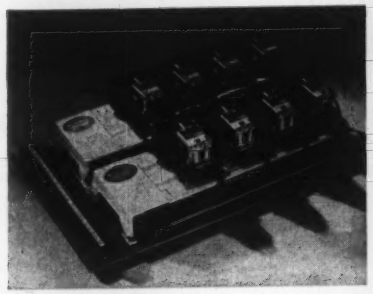
external heat load, cold junction temperature is −15 C. For generation purposes, an output power of approximately ¼ w can be obtained from each unit with temperature difference of 150 C. Units can be combined for greater capacities by connection in series, parallel, or cascade. Junction is available in experimental quantities. **Ohio Semiconductors Inc.**, 1035 W. Third Ave., Columbus 8, Ohio G

Circle 679 on Page 19

Wiring System

uses depth behind relays for compact control-panel layout

Wyr Way units are of hinged aluminum, modular construction with



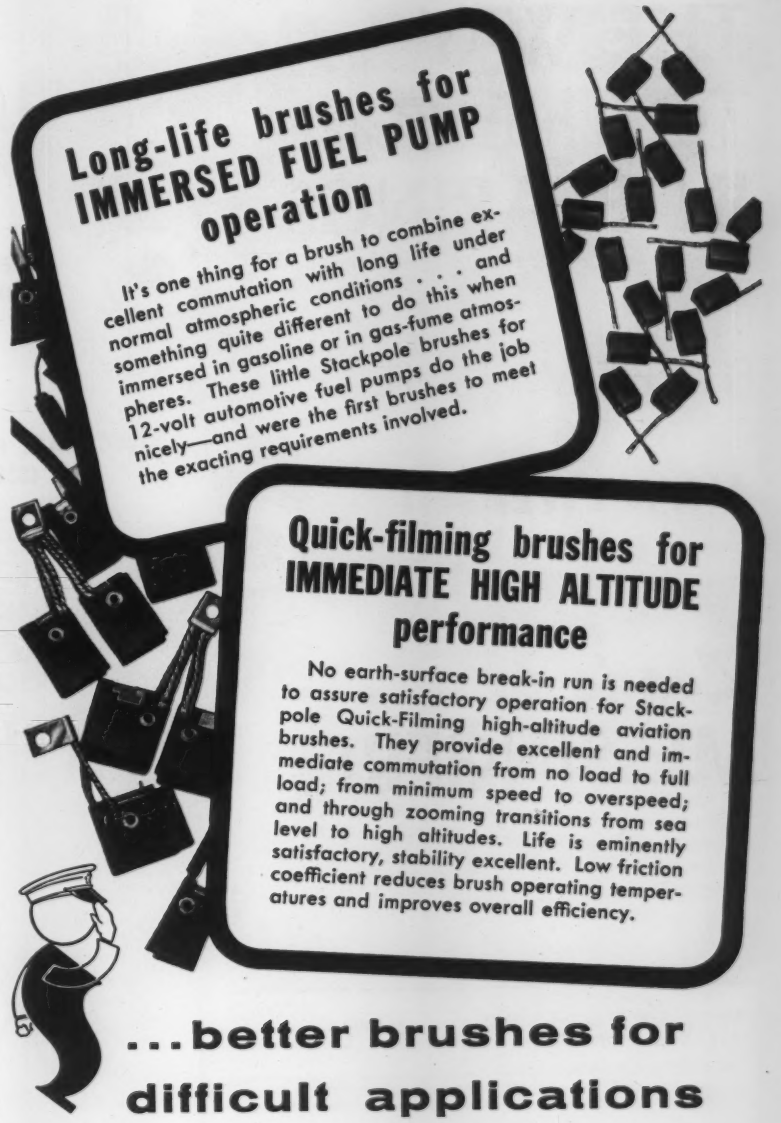
built-in wiring compartments. Relays are mounted on top surface and control wires are contained under the devices. Each module swings out so control wires can be snapped into place behind flexible vinyl retaining fingers. Units provide for containing both horizontal and vertical wiring. System is designed to utilize depth behind relays in building control panels. It permits compact mounting of relays and results in use of considerably smaller panel enclosures than previously possible. **Wyr-Way Inc.**, 250 Mt. Hope Ave., Rochester 3, N. Y. N

Circle 680 on Page 19

Spray Nozzle

provides either 180 or 160-deg pattern

Span-Jet nozzle is a wide-angle, circular-spray type which has applications in spraying or washing insides of tubular units, in air washers, roof cooling, and various chemical processes. Unit is available in two styles to provide either a



Long-life brushes for IMMERSED FUEL PUMP operation

It's one thing for a brush to combine excellent commutation with long life under normal atmospheric conditions . . . and something quite different to do this when immersed in gasoline or in gas-fume atmospheres. These little Stackpole brushes for 12-volt automotive fuel pumps do the job nicely—and were the first brushes to meet the exacting requirements involved.

Quick-filming brushes for IMMEDIATE HIGH ALTITUDE performance

No earth-surface break-in run is needed to assure satisfactory operation for Stackpole Quick-Filming high-altitude aviation brushes. They provide excellent and immediate commutation from no load to full load; from minimum speed to overspeed; and through zooming transitions from sea level to high altitudes. Life is eminently satisfactory, stability excellent. Low friction coefficient reduces brush operating temperatures and improves overall efficiency.

...better brushes for difficult applications

These milestones in better brushes for unusual conditions are typical of Stackpole brush progress along many lines. Equally important in their respective fields, are Stackpole brush developments for diesel-electric equipment, fractional horsepower motors, silicone-insulated motors, electro-plating generators, heavy-duty motors and others. For prompt brush recommendations, send details of your application to: STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE BRUSHES

for all rotating electrical equipment

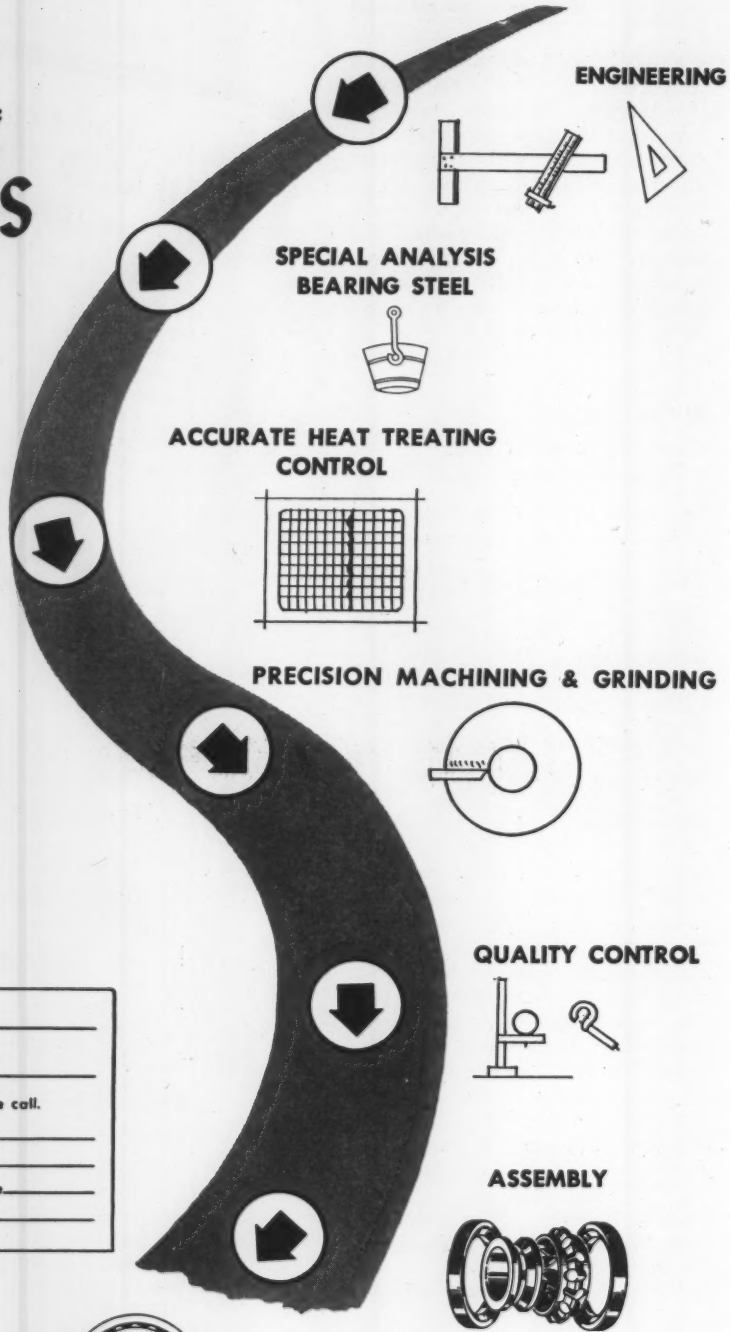
Contacts • Bearings • Graphite Chemical Anodes • Grounding Anodes • Power Tube Anodes • Seal & Clutch Rings • Voltage Regulator Discs • Heating Elements • Friction Segments • Ceramic Magnets • Ferromagnetic Cores • Fixed & Variable Resistors . . . and many other carbon, graphite and metal powder products.

Circle 537 on Page 19

THE WAY TO THE *Best* IN BEARINGS

FEATHERWEIGHT
to
HEAVYWEIGHT

Leads to MESSINGER!



MESSINGER BEARINGS, INC. Date_____
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We are interested in Bearings for_____ (Application)
☐ Please send literature. ☐ Have your representative call.
Company_____
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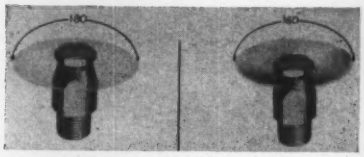
BALL AND ROLLER BEARINGS • FEATHERWEIGHT TO HEAVYWEIGHT



180-deg, flat circular spray pattern or a 160-deg hollow-cone spray pattern. Nozzle is made in capacities from 0.75 to 10 gpm at 40 psi pressure. Standard nozzle has a male connection to fit pipe sizes of 1/8, 1/4, and 3/8 in. It is available in brass, 303 stainless steel, or special materials. Wm. Steinen Mfg. Co., 43 Bruen St., Newark, N. J. D

Circle 681 on Page 19

Flexible Tubing

for use in lubrication and air lines

Flexible, lightweight pneumatic and hydraulic tubing, known as Synflex N3, is a natural-color polyamide formulation for permanent use in lubrication systems, instrumentation, vacuum, chemical and effluent lines, and air lines for equipment and tools. Low-pressure tubing is available for applications to 1500 psi, and medium-pressure tubing for service to 2500 psi. Both types have OD of 1/8, 3/16, 1/4, 5/16, or 3/8 in. Wall thickness varies with intended service, OD, and other factors. Normal maximum operating temperature is 150 F. Tubing is shipped in standard coil sizes of 500 ft in heat-sealed polyethylene bags to preserve moisture content. Synflex Products Div., Samuel Moore & Co., Mantua, Ohio. G

Circle 682 on Page 19

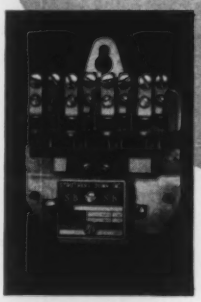
Flash Tube

tiny unit has bright light output

FX-6A xenon-charged flash tube is 7/8 in. long and 7/8 in. in diam. Peak light output is 3500 horizontal candle power at flash duration of about 3 mu sec. Under maximum power input, tube has a half-light output expectancy of at least 20 million flashes; by derating input conditions, life of 100 million flashes can be attained. Tube produces a nonwandering arc discharge of high efficiency, achieved by use of six probes placed between two

RUGGED REVERSING CONTACTOR

without costly auxiliary "frills"



NON-REVERSING TYPES

Dunco 3- and 4-pole contactors for motor control uses combine small size and long life with maximum economy. Similar ratings. Write for Dunco Bulletin 7048.

This sturdy, Type A175KXX Dunco reversing contactor is small, yet designed for utmost simplicity and ruggedness. Unsurpassed for continuous use and frequent jogging service on hoists, machine tool controls, door openers and the like. And the price is low! The only auxiliary is a mechanical interlock to prevent simultaneous closure of both sets of contacts.

Substantial double-break action assures long life even under highly inductive loads. Rated at 15 amps. to 600 V. AC and up to 3 h.p. for 440/550 volt AC 3-phase service. Write for Dunco Data Bulletin 7100.

STRUTHERS-DUNN, Inc.

World's most diversified relay selection

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Sales Engineering Offices in: Atlanta • Boston • Buffalo • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto

Circle 539 on Page 19

NEW HAMPSHIRE BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

NEW TECHNIQUES SOLVE SHIELDING AND IDENTIFICATION PROBLEMS

For some time, now, the precision instrument bearing industry has been searching for the solutions to two problems: (1) *how to develop a more effective shield;* (2) *how to provide visual identification for parts as small and precise as instrument bearings.* Exhaustive research in both areas has finally borne fruit for New Hampshire Ball Bearings, Inc. Both problems have been solved. The solutions seem so simple that it's surprising they weren't discovered long ago.

MORE EFFECTIVE SHIELD

What a big difference a slight change from traditional design can make! By eliminating the recess in the inner ring, New Hampshire's design engineers have reduced by more than 70% the size of the dirt particles that can get into the bearings.

The primary function of a shield is to keep dirt out of the bearing. A contact seal between the two rings wouldn't do. It would increase torque and cause wear. The rings must be able to turn independently. So, the idea is to close the gap as nearly as practicable.

Fig. 1

Fig. 2

The conventional answer, (Fig. 1), inherited from large bearings, falls down badly. Because the recess has to be machined instead of accurately ground, the gap between shield and recessed surface is as high as .007", while that between shield and shoulder is even higher. This means that dirt particles as large as .007" can get in. With large bearings this is not too serious a problem. But with some of the small bearings, such particles are ¼ as large as the ball. That creates a serious torque and wear problem.

Defenders of the old design argue that the recess creates a "labyrinth" effect that discourages entry of large particles. New Hampshire designers maintain, however, that a smaller gap is the more effective answer.

New Hampshire's design, *(Fig. 2)*, closes the gap to .002" or less than ⅓ that of the old design. This close tolerance is made possible by fitting the shield to the precision ground O.D. of the inner rings. This simplified design has no corner where dirt and dust can collect to cause drag between shield and ring. It also provides a broader reference surface for the mounting.

VISUAL IDENTIFICATION

A new marking system, recently introduced by New Hampshire Ball Bearings, Inc. gives you three important pieces of information at a glance. When you see the marks, you know that the instrument bearings are made by New Hampshire . . . that you are getting ABEC 7 tolerances or better at no extra cost . . . whether they're made of stainless steel or chrome steel.

Here's the code. Sets of double lines 120° apart indicate Stainless Steel, *(Fig. 3)* . . . 180° apart, Chrome Steel, *(Fig. 4)*. Such visual identification assures correct deliveries by New Hampshire, correct application by you.

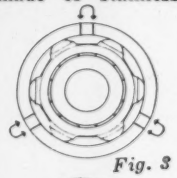


Fig. 3

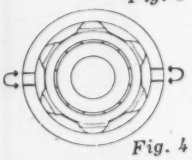


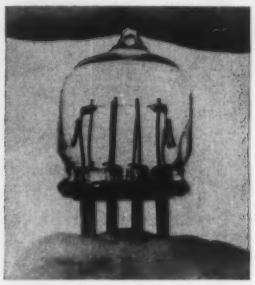
Fig. 4

Notice that the marks are applied to one face of the outer ring where research proves there can be no detrimental effect on performance, mounting characteristics or bearing life. Marks are applied by impact before grinding and heat treating. They cause no dimensional change, distortion or destructive effect on finish.

HANDBOOK FREE TO ENGINEERS

This authoritative, 80-page handbook contains everything you need to know to help you incorporate miniature ball bearings in instruments and electro-mechanical assemblies. It will be sent free to qualified engineers, draftsmen and purchasing agents.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.



electrodes in a relatively high-pressure gas field. Operating range is 400 to 1200 v, triggered by a low-current, high-voltage pulse of 4 to 7 kv. Standard nine-pin socket permits chassis mounting. Applications include stroboscopic studies and analog-digital readout, use in shaft-position encoder, cold-cathode switch tube, microfilm recorder, and constant-reference light source. **Edgerton, Germeshausen & Grier Inc.**, 160 Brookline Ave., Boston, Mass. B

Circle 683 on Page 19

Miniature Dome Nuts

are now available in ¼-28 thread size

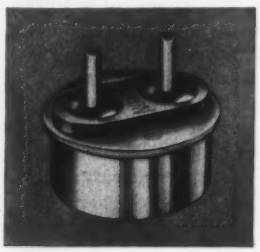
Self-sealing miniature dome nuts are available in ¼-28 thread size. Materials are alloy steel or corrosion-resistant steel to withstand temperatures to 400 F. **Nutt-Shel Co.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L

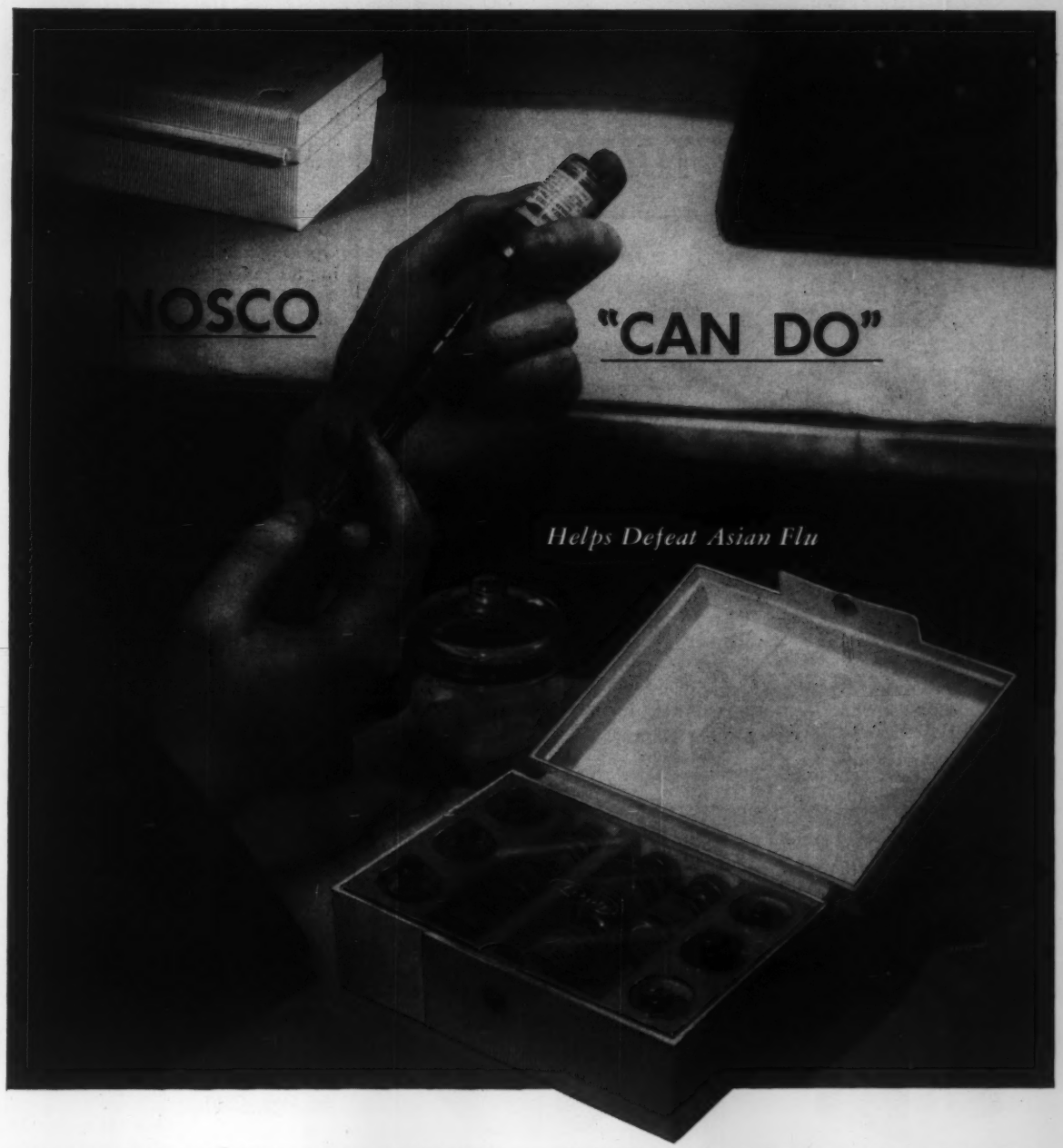
Circle 684 on Page 19

Miniature Thermostat

has 9-F differential for close temperature control

High-reliability version of Klixon M1 thermostat is designed for missile and other critical applications. Low differential of 9F provides close temperature control in 60 to 225-F range. Miniature, hermetically sealed unit features all-welded





Yes, Nosco's famous "Can Do" ingenuity is contributing to a healthier America. Where doctors are fighting Asian Flu, you'll find this custom-molded Nosco Biological Kit by their side.

Lederle Laboratories wanted to make their precious flu vaccine easier for doctors to preserve and transport. They came to Nosco with their special requirements for a multi-vial carrying case. The container had to demonstrate striking clinical cleanliness and easy washability. Great shock resistance and chemical inertness were also necessary. And cost was important.

Nosco said "Can Do" and began transforming customer specifications into practical design. From flexible polyethylene they molded the container with an integral hinge for connecting the base and cover. A white expandable styrene liner was assembled into the base to give additional shock and thermal insulation. Further protection is provided for the vials by the clear acrylic panel, which hinges freely with the case by means of integral pivot lugs.

Nosco's finishing department hot stamped "BIOLOGICALS" into the cover and crimped male and female eyelet elements into the case. Finally, the assembled composite units were individually plastic-bagged to preserve the clinical quality.

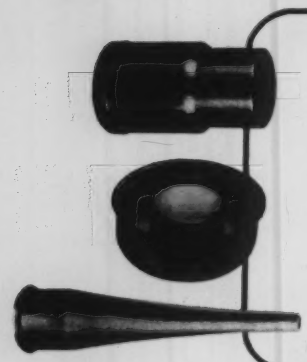
Complex projects like this biological kit are routine at Nosco. In injection molding and decorating, Nosco "Can Do" is time tested. Let us show you how these skills can produce your plastic parts in volume and at reasonable costs. For more information, just write or call.

NOSCO plastics, inc. · erie 5, pa. *One of the world's great injection molders.*

Circle 541 on Page 19

Schrader Metal Spinnings & Hydroformings

• CUT TOOL AND DIE COSTS
• HOLD CLOSE TOLERANCES



PUMP COVER
⅛" stainless machined to ±.005.

STAINLESS STEEL SHROUD
Radius and dia. held to ±.001.

COPPER RESISTOR HOUSING
Wt. is ±¼ oz. on finished part.

Schrader engineers have had extensive experience in producing odd shapes, short runs, and experimental parts with a minimum of set-up and tooling costs.

Write for Brochure
Dept. MD-7

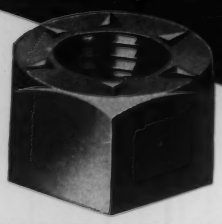
Since 1897

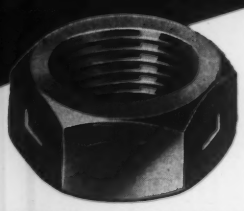
J. Schrader Company
4603 FENWICK AVENUE, CLEVELAND 1, OHIO

Circle 542 on Page 19

2 GRIPCO LOCK NUTS

at low cost that can save you production time, speed application, and resist vibration



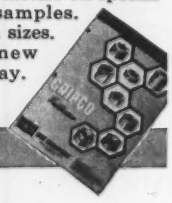


GRIPCO LOCK NUTS

Simple, one piece design, no inserts, no separate locking devices, nothing complicated. The locking action is within the nut itself and you get low initial cost with lower application costs, WITH increased customer satisfaction. Ask for your samples now.

CENTER LOCK NUT

Can be applied from either end, double chamfered, with locking feature in the center. Greater application speeds now possible. Automatically fed, they will lock wherever turned on bolt. Available in steel from stock. Other metals on special order. Send for samples. Complete data on sizes. Write for this new FREE catalog today.



ALL GRIPCO FASTENERS AVAILABLE FOR IMMEDIATE DELIVERY

GRIP NUT COMPANY
103 Maple Ave. • South Whitley, Ind.

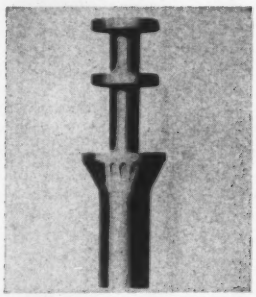
Circle 543 on Page 19

construction, and is independent of solders, fluxes, or organic materials. High vibration-resistant construction tests to 25 g in frequency range of 75 to 3000 cps. Actuating device is a snap-acting bimetallic disc. Rating is 5 amp maximum at 30 v dc, 100,000 cycles minimum. Opening tolerance is ±5 F and closing tolerance, ±4 F. **Metals & Controls Div., Texas Instruments Inc.,** 34 Forest St., Attleboro, Mass. B

Circle 685 on Page 19

Vibrationproof Terminal

for etched-circuit and terminal boards



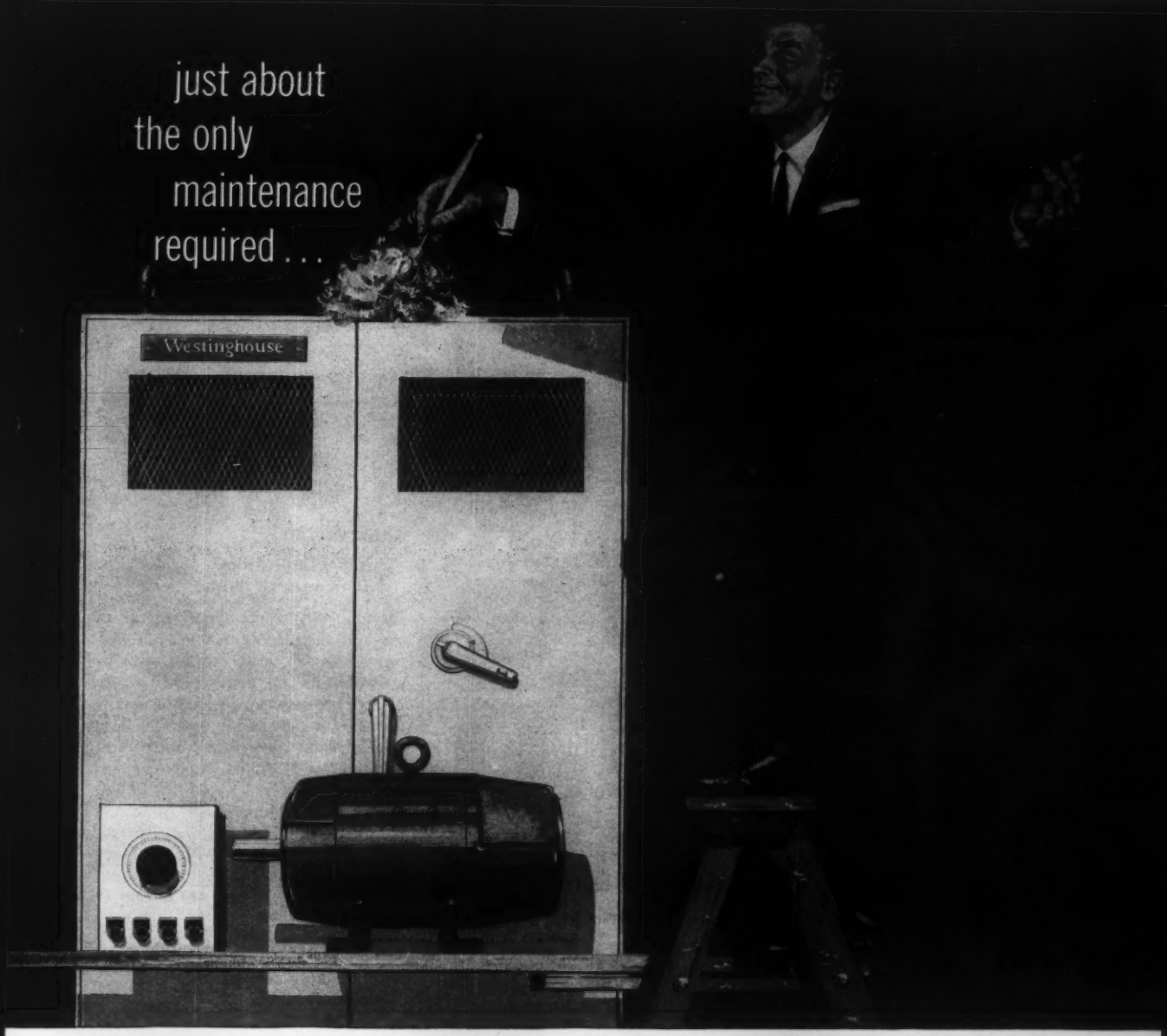
Featuring a countersunk and knurled shank which provides superior electrical and mechanical contact, Vibrapruf terminal is available for etched-circuit and terminal boards. Shank insures protection against loosening in the board. Terminal uses less surface area on top side of plated board, but provides more contact-surface area, electrically and mechanically, within countersunk portion of plated hole. Considerable increase in g-loads is possible. **Hu-Bar Terminals, Inc.,** 8721 Rindge Ave., Playa del Rey, Calif. F

Circle 686 on Page 19

Adjustable-Speed Drives

have up to 6:1 speed variations

Models 65 and 70 frame Varidrive adjustable-speed transmission and integral motor are used for ratings between 30 and 60 hp with rugged, compact design. Model 65 is a single-belt drive rated to 40 hp with up to 6:1 speed variations. Capable of 60 hp, 70-frame unit has dual belts and is also available with up to 6:1 speed variations. Both mod-



New Type AVR static-powered adjustable-speed drive

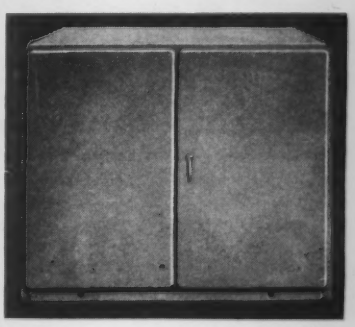
With the new Westinghouse static-powered AVR adjustable-speed drive, maintenance costs are virtually a thing of the past. Power magnetic amplifiers replace the conventional motor-generator set . . . there are no moving parts to weaken from wear and fail . . . you enjoy all the proven benefits of static control components.

Providing smooth, stepless speed control, new AVR drives are designed for use with motors from 1 to 200 hp . . . give you constant torque over an 8 to 1 speed range, or 10 to 1 with modification . . . are also available with constant-horsepower speed ranges.

New Westinghouse AVR drives are completely engineered, assembled and factory tested. They provide higher operating efficiency with greater reliability than heretofore obtainable from conventional drives. They simplify installation and reduce floor space required . . . sometimes as much as one-half the area of conventional M-G set drives.

Ask your Westinghouse sales engineer to show you exactly where and how you can benefit from new Westinghouse adjustable-speed drives. Or, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-22144

Also available . . . the new, redesigned motor-generator Type AV drive with new silicone-insulated Life-Line® "H" d-c motor, new electronic regulators which simplify maintenance, and positive-pressure ventilation for longer, trouble-free life.



YOU CAN BE SURE... IF IT'S **Westinghouse**

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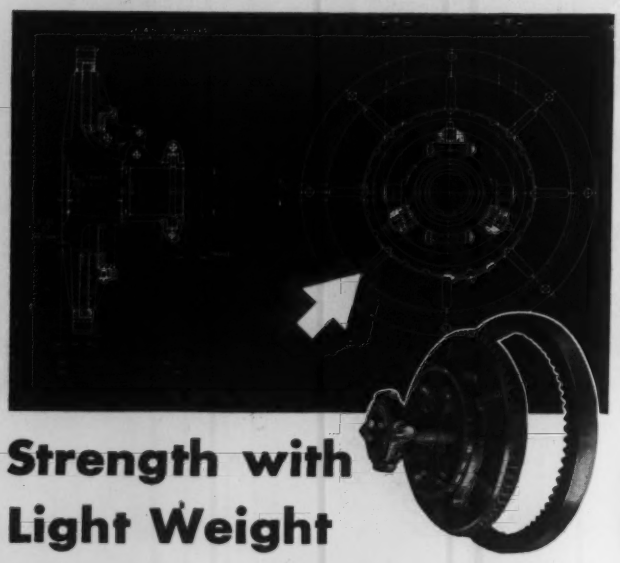
Circle 544 on Page 19

ROCKFORD



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Strength with Light Weight for Heavy-Duty Work

Ribbed construction, in ROCKFORD HE Over-Center CLUTCHES, provides strength, without undue weight, to the clutch body and pressure plate. Driving pressure is applied toward the outside of the facing to assure that ROCKFORD CLUTCHES will continue to pull their full rated load during their long service life—particularly in power take-off applications. The load is carried by teeth on the outside diameter of the facing member. While your power transmission control projects still are in the planning stage, it will pay you to consider how this ROCKFORD CLUTCH will provide added strength with less weight.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

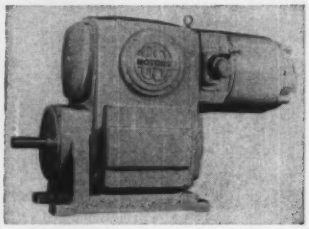
ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES



els feature sturdy sub-base construction to permit upright or horizontal mounting. Variety of remote controls is available. **U. S. Electrical Motors Inc.**, Box 2058 Terminal Annex, Los Angeles 54, Calif. L

Circle 687 on Page 19

Servo Motor

size 5 unit provides 0.10 oz-in. stall torque

Developed to meet requirements of air and missile-borne guidance systems, size 5 servo motor weighs only 0.6 oz and delivers 0.10 oz-in. of stall torque. Power requirements are 1.5 w per phase at 26 v, 400 cps. Under these conditions, unit accelerates at 39,000 rad per sec per sec until free speed of 10,000 is reached. Moment of inertia is 0.18 gm-cm². **Daystrom Transicoil Co.**, Worcester, Montgomery County, Pa. E

Circle 688 on Page 19

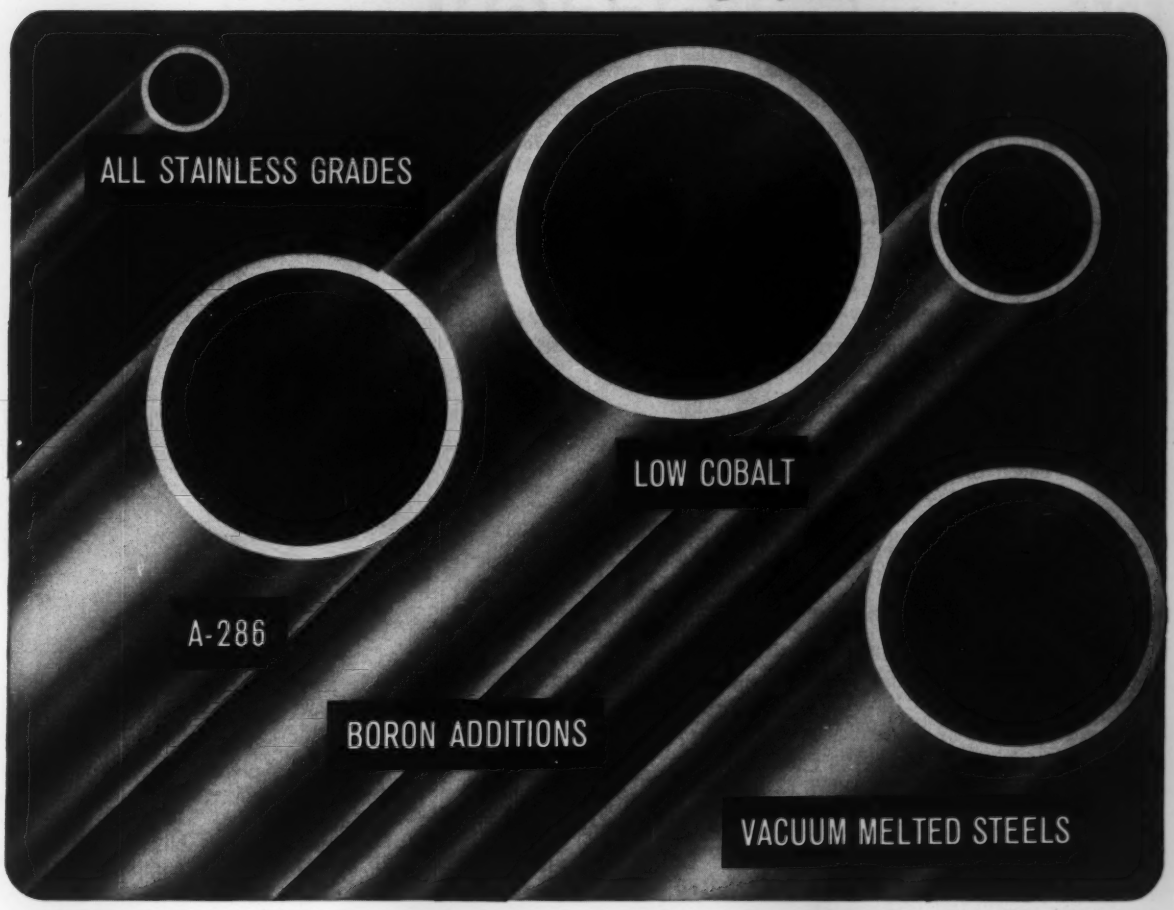
Silicone Rubber Compound

for making semicured electrical tapes

New silicone compound, SE-101OU, is designed for use in the fabrication of semicured electrical tapes. It makes possible a reinforced type of silicone insulated system that will extend service life and reliability of electrical equipment over a wide range of environmental conditions. Reinforced silicone-rubber insulation made with SE-101OU combines superior mechanical properties with essentially same electrical properties found in unsupported silicone-rubber insulating systems. Semicured electrical tapes possess high interply bond strength, improved shelf life, outstanding voltage aging characteristics and excellent corona resistance. **Silicone Products Dept., General Electric Co.**, Waterford, N. Y. C

Circle 689 on Page 19

Experience** — the added alloy in **Allegheny Stainless



What are your needs in Seamless Tubing?

A-L offers widest range of materials and large diameters with walls as thin as .032".

Here is the widest range in materials in stainless seamless tubing available anywhere to meet your exact requirements and solve high-temperature or corrosion problems and save you money.

Allegheny Ludlum makes seamless tubing in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. Also available in high-strength alloys such as A-286, in vacuum melted steels, and in custom analyses grades such as low cobalt with .01 or .05 max. and small boron additions to standard types.

A-L also makes composite tubes with bonded combinations of carbon and stainless and other metals for special chlorine-corrosion applications in process equipment.

Allegheny Ludlum Stainless Tubing ranges from 3/16" OD to 3½" OD with wall thickness ranging from .013" to .375"—typical of the sizes that A-L can produce. For certain applications, .500" walls are possible. Some standard sizes in stock are 2½" OD—.032" walls, 3" OD—.042" walls and 3½" OD—.042" walls and 3½" OD—.058" walls. All sizes with true circularity, no dents or handling marks.

A-L Tubing is also available in small quantity orders, in random or cut lengths. Standard grades and sizes in stock throughout the country. Call your nearest A-L representative for all the help you need.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MD-19.

NEW! FREE—Write for your copy of Allegheny Ludlum Stainless Tubing—32-pages of technical data, grades and suggested applications.

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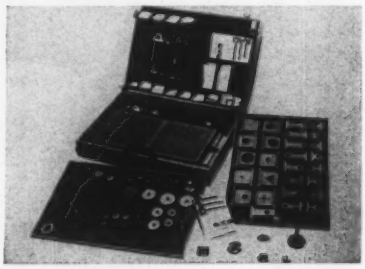
ENGINEERING DEPARTMENT

EQUIPMENT

Breadboard Kits

in 1/8, 3/16, and 1/4-in. shaft diam

Nine Master breadboard kits in Precision 1, 2, and 3 tolerances are available in 1/8, 3/16, and 1/4-in. shaft diam. Kits contain over 2000



different precision items, including gears, speed reducers, differentials, and limit-stop assemblies. Components are adaptable to all mechanical and electronic applications. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 690 on Page 19

Ink Dispenser

permits one-hand filling of drafting instruments

Drawing-ink dispenser, called Ink-A-Matic, permits filling of drafting instruments almost automatically, with one hand. Ink bottle stands securely in nonskid rubber base. Light touch on lever at side lifts stopper, bringing pen filler into position for supply of right amount of ink to ruling instruments. Pen can

PROGRESS IN PLASTICS

Complex cover part made inexpensively from Dilecto grade XF—phenolic laminate with a kraft paper base.

POSTFORMING—THE INEXPENSIVE WAY TO MAKE COMPLICATED PARTS

How it's done. Briefly, postforming is effected by heating Dilecto stock until it is pliable, then placing it in an unheated, inexpensive mold, and pressing until the laminate cools enough to retain its shape.

Less expensive. Postforming is less expensive than other molding methods, because, generally, lower-cost dies and tools can be used. Frequently, dies can be constructed of wood or plastics rather than of tool steel. Also, retooling to meet new specifications is cheaper. Dies are more adaptable. Labor costs are reduced.

Why Dilecto? Dilecto plastics laminates are excellent for postforming applications where the following qualities are required: high strength-weight ratios, superior electrical and chemical properties, and resistance to abrasion, weathering, moisture, and corrosion. Light weight is another major Dilecto asset.

Special Dilecto grades. Special Dilecto postforming grades respond to sharper bends and deeper draws, and take more complex contours without fracturing. However, most grades of Dilecto can be postformed to a limited extent. CDF Technical Bulletins 21 and 46 describe postforming grades in detail.

CDF silicone-rubber tapes insulate Electro-Flex heaters

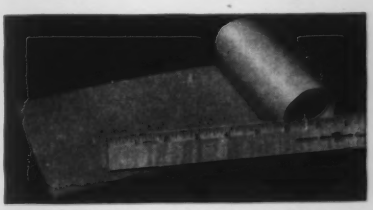
Bread on the "sandwich". Construction of Electro-Flex heaters consists of a vulcanized "sandwich" of silicone-rubber tape on both sides of patterns of resistance wire. Standard Electro-Flex heaters consist of four plies of CDF silicone-rubber tape (woven glass-fiber cloth with silicone-rubber calendered on). Each ply is .010-in. thick. For extreme flexibility, this CDF customer makes a Hi-Flex (trade name) heater.

Heat up missiles and rockets. Electro-Flex heaters are on all U.S. missiles and rockets. Typical are the Atlas, Thor, and Redstone, where they heat pipes and valves in the fuel system. Industrial applications include storage-drum heaters, heat sealing, and oven heaters — particularly small crystal ovens. CDF supplies 80% of the silicone-rubber tapes used by Electro-Flex. Request Bulletin SR-3.

Flexible Teflon-impregnated glass cloth

Combines advantages. Flexible new Dilecto GB108TED combines the high tensile strength and resistance to flow typical of glass-cloth laminates with the low permeability, excellent chemical resistance, and superior electrical properties of DuPont Teflon TFE fluorocarbon resin. It consists of glass cloth impregnated and covered on both sides with a continuous film of Teflon resin. An important advantage: freedom from pinholes.

Where it's used. Dilecto GB108TED is suitable for corrosion-resistant parts like gaskets and seals. Also for electrical insulation like radar windows, flexible printed circuits, and tape cable. It shows unusually high tear-resistance, and can be formed into simple shapes. Request Bulletin GST-58A.



Dilecto GB108TED is offered as continuous, natural-color, smooth-finish sheet in coils. Maximum width 6". Maximum length 75'.

NEW CDF LITERATURE • *Bulletins referred to in this advertisement may be obtained from your CDF representative, or you may send the coupon below, indicating the Bulletins you want.*

Please send me the following Technical Bulletin(s):

- ☐ Bulletins 21 and 46 — CDF Postforming Grades
- ☐ Bulletin GST-58A — CDF Teflon-impregnated glass cloth
- ☐ Bulletin SR-3 — CDF Silicone-Rubber tape

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A SUBSIDIARY OF THE Budd COMPANY • NEWARK 23, DEL.

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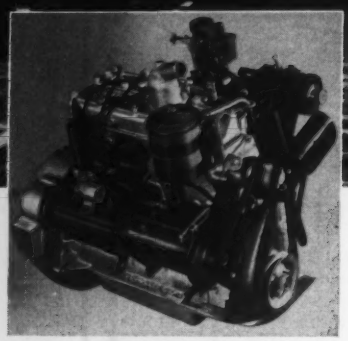
Tough Jeep L-4 engine jockeys 78,000 lb. railroad car.



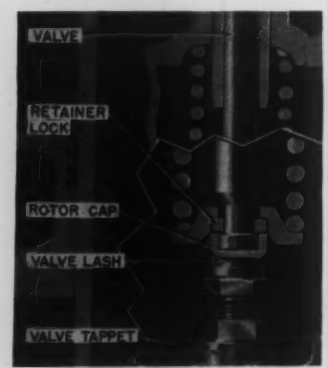
for 20-40 H. P. industrial engine needs . . .

this Jeep® means business

The forerunner of this engine pulled the famous Jeep through two wars. Willys engineers *improved* on that great engine, to produce the outstanding L-4. This engine was built with a *job* in mind — the job of giving rugged, reliable power for industrial use.

The smoothness of a six . . . the economy of a four

"Keypoint" engineering gives the Jeep L-4 its extra stamina: the parts that do the most work are built the strongest — just one example of the sound engineering sense that goes into Jeep engines, keeping them in their best fighting trim.



Positive valve rotators assure clean, even-wearing valve seats.

This outstanding 4-cylinder L-head engine has:

- **Full hard-chrome plated top compression rings**
- **Positive valve rotators**
- **Hard faced stellite valves**
- **Positive crankcase ventilation**

Send for complete information on Jeep 4 and 6 cylinder industrial engines.

KAISER WILLYS MOTORS

WILLYS MOTORS, INC.
Industrial Engine Dept., Toledo, Ohio

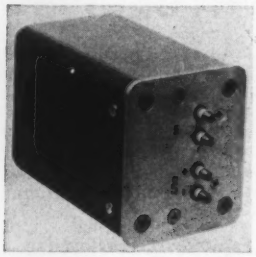
be rotated for most convenient filling angle. Lever can be clamped back so bottle stays open when dip pen is used. Left or right-hand units are available. **Higgins Ink Co.**, 271 Ninth St., Brooklyn, N. Y. D

Circle 691 on Page 19

DC Power Supplies

are miniature, highly regulated units

Miniature, transistorized, highly regulated dc power supplies operate from 115 v ac, 50-60 or 400 cps, and wire into circuit like conventional potted transformers or chokes. For 50-60 cps input, 36 models cover nine output voltages from 3 to 36 v dc in approximately 14 per cent increments, with output power capacities of 2, 4, 8, and 15 w. The



same number of models is available for 400-cycle input. Voltage regulation is ± 0.05 per cent against line and load variations, and ripple is less than 0.01 per cent. Applications include use as high-stability supplies for a variety of transistor circuitry, regulated supplies for strain gages and other transducers, regulated bias or power supplies for vacuum tubes, and highly stable dc reference voltage sources. **Sorensen & Co.**, South Norwalk, Conn. B

Circle 692 on Page 19

Drawing Set

is available in high-impact case

Sigma drawing set contains rugged, nickel-silver and steel instruments which are warranted for lifetime use. Case is high-impact, nonbreakable plastic that will not rust, warp, or bind. Flip-stand cover makes all instruments easily and instantly accessible. **Eugene Dietzgen Co.**, 2425 N. Sheffield Ave., Chicago 14, Ill. J

Circle 693 on Page 19

Clark simplifies axle machining with

DAYTON SEMI-BONDED BUSHINGS

Here's an example of how "Engineering in Rubber," the Dayton way, is used on Clarklift fork trucks. It's a unique viewpoint on the application of sound engineering principles to discover a newer, simpler, more economical way to make rubber do a bigger job for your design.

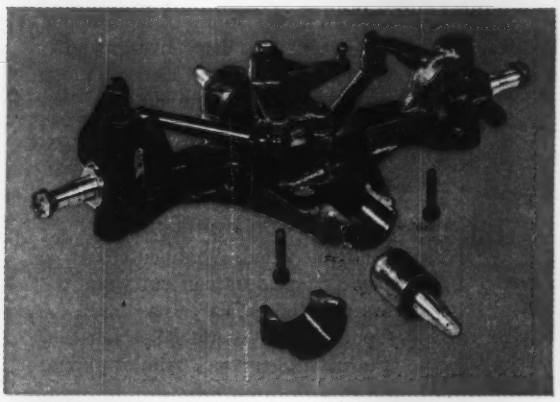
Clark Equipment was doing a good job with the rubber bushings on which the steer axle pivots. But there's always a better way and, working with Dayton engineers, Clark found it.

Look at the results . . . a new Dayton semi-bonded bushing. Delivered ready for assembly, it eliminates a separate bushing cap, an expensive boring operation, plus assembly time before and after machining.

Yet there's no functional difference between this and the older type bushing. Dayton did improve the characteristics by adhering the rubber to the inner metal shaft with a lifetime bonding process . . . reducing the level of pre-compression by nearly ½ in a bushing which must permit up to 3" of articulation in the pivoting axle.

This is what Dayton means by "Engineering In Rubber." It's a design approach that can solve your problems of vibration, shock, and noise control . . . correct inherent misalignment . . . simplify assembly . . . and reduce maintenance costs. The result is better quality at a competitive price.

Fill out and mail the coupon below. It will bring you the prompt, efficient services of a molded products specialist and start you on the way to new savings.



COMPARE THIS METHOD—The conventional way is the more complex way to mount the steer axle to the frame. First the bushing cap must be shimmed and bolted down, the inside diameter bored, the cap disassembled and the shims removed, and the cap replaced again when the bushing is finally installed.

WITH THE DAYTON METHOD—Delivered ready for final assembly, the Dayton semi-bonded bushing is easily bolted into place rapidly and efficiently. Notice, too, how the axle casting has been simplified now that in-line boring is no longer required.

RUBBER · RUBBER-TO-METAL · RUBBER-TO-FABRIC

Dayton Rubber

MOLDED PRODUCTS SALES DIVISION • Three Rivers, Mich.

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THE DAYTON RUBBER CO., MOLDED PRODUCTS SALES DIV. THREE RIVERS, MICHIGAN

I have a design requirement and would like to talk more about it with one of your sales engineers.

*Name*_____

*Company*_____

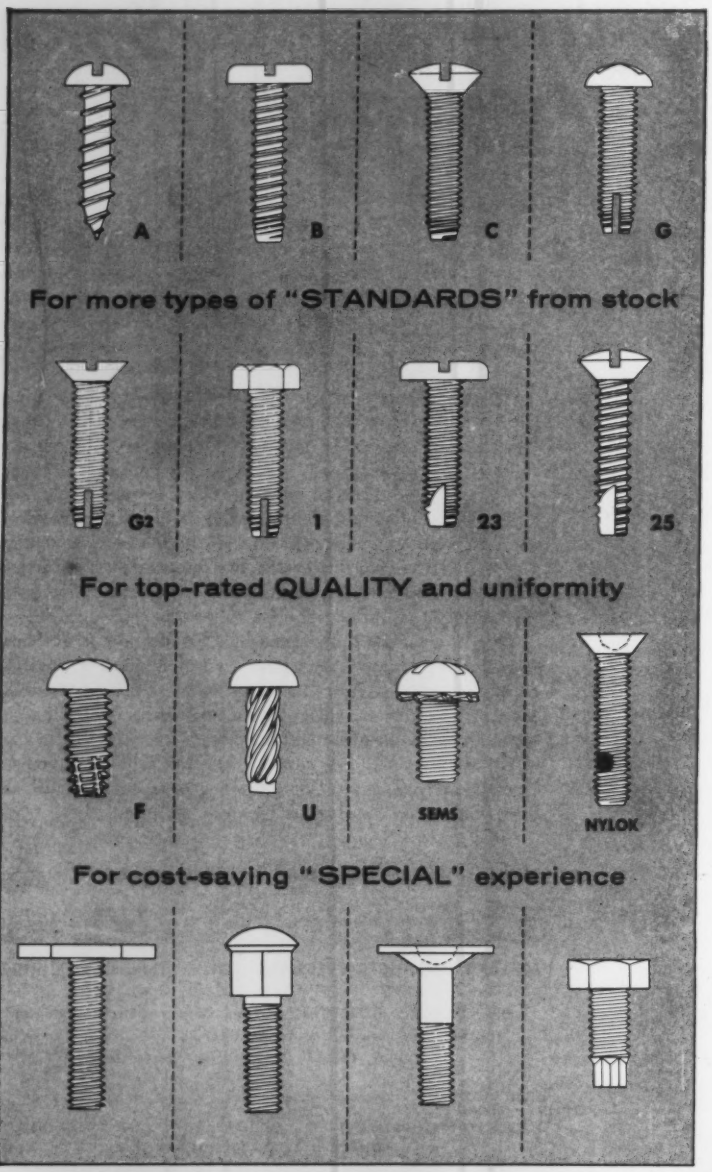
*Address*_____

*City & State*_____

Count on *Continental* to show you why

you can measure the difference in assembly dollars

when you use the right type for the job



Which fasteners will serve best and save most in your assemblies? Many types of screws look much alike, but the difference between the right and wrong choice for your job can often make a big difference in assembly costs.

Since Continental makes and supplies *all* types, their recommendations are unbiased. They can tell you if you should be using some "standard" you have overlooked. Or, if a "special" will save you most, you can rely on Continental's specialized experience to design and produce it at the lowest possible cost.

CHECK YOUR ASSEMBLIES

Find out where Continental's cost-saving ideas can cut your assembly costs. Talk to a Continental Assembly Specialist. For prompt service, write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

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THE ENGINEER'S

Library

Recent Books

Handbook of Air Conditioning, Heating, and Ventilating. *Edited by Clifford Strock; 1112 pages, 7¾ by 10¾ in., clothbound; available from The Industrial Press, 93 Worth St., New York 13, N. Y.; $15.00 per copy.*

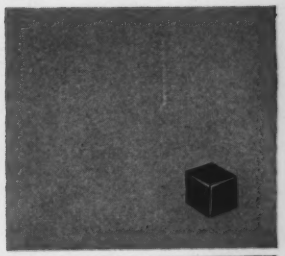
Information in this volume is intended primarily for the design of air conditioning and heating installations in buildings. However, much of it is applicable to equipment where heating, cooling, duct work, plumbing, dust collection, etc., are involved.

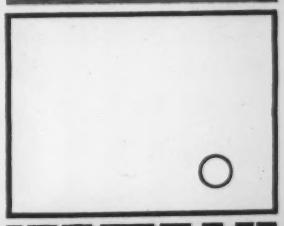
Since emphasis is on working data, tables and charts of engineering solutions predominate. Sections cover all fuels and their combustion data, heat transfer, piping and plumbing, motors and starters, mathematical data, and terminology. Included are tables of heat losses from insulated pipe, data on steam flow in pipes, design of high-velocity and dual-duct systems, data on plastic pipe and tube, and psychrometric tables and charts.

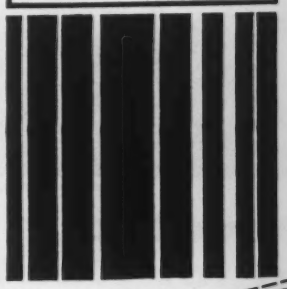
High Temperature Materials. *Edited by R. F. Hehemann and G. Mervin Ault; 544 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$17.50 per copy postpaid.*

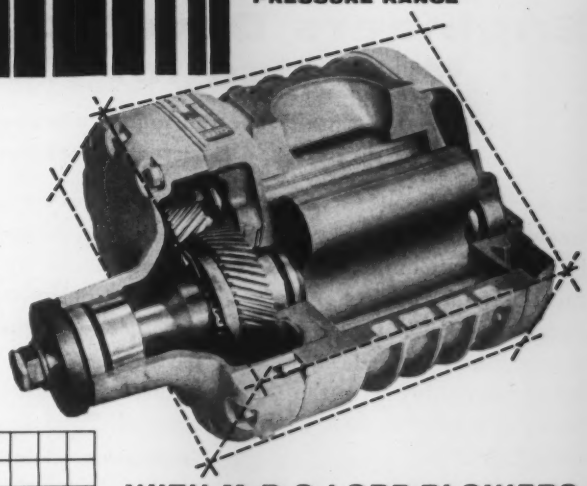
Papers presented at the 1957 symposium sponsored by American Institute of Mining, Metallurgical, and Petroleum Engineers summarize the characteristics and performance factors of nickel and cobalt-base alloys, cermets, and intermetallics good for 2000 F temperatures. Higher-temperature refractory metals are also discussed.

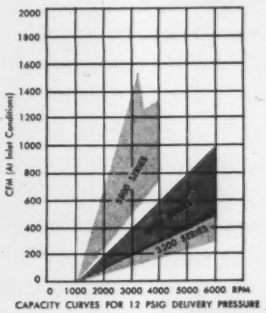
Dispersion hardening for high-strength properties is investigated for various base metals. Gas-metal interactions and vacuum melting are reviewed as methods for obtaining property improvements. Resistance of high-temperature alloys to


SMALLEST CUBE DIMENSIONS


LIGHTEST WEIGHT


WIDEST PRESSURE RANGE





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If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

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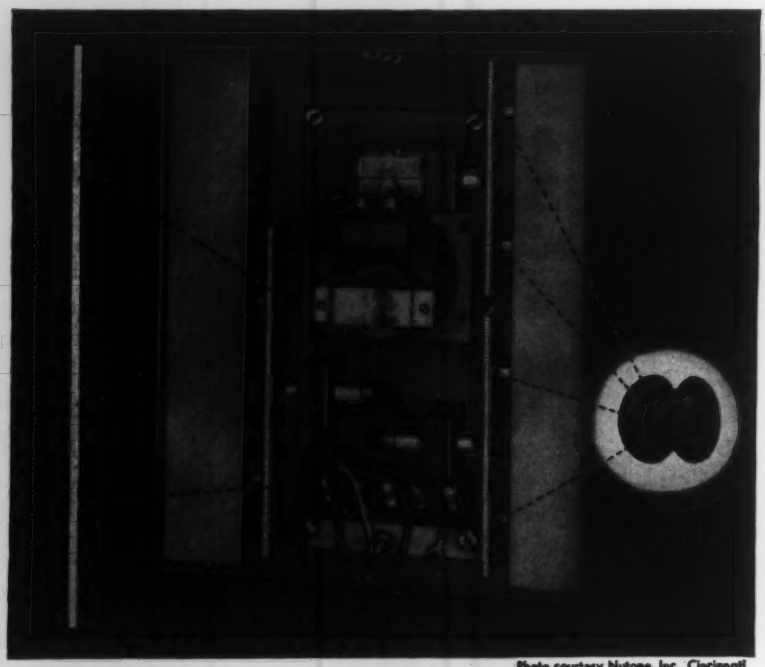

Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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oxidation is considered. Effects of test environment on material behavior at high temperatures are also analyzed.

New Standards

American Standards. *Publications listed below are 8½ by 11 in., paperbound, and stapled. Copies are available from American Standards Association, 70 East 45th St., New York 17, N. Y.*

American Standard Z1.1-1958, Guide for Quality Control. Combined with Z1.2-1958 into one publication.

American Standard Z1.2-1958, Control Chart Method of Analyzing Data. 28 pages; includes Z1.1-1958; $2.25 per copy.

American Standard Z1.3-1958, Control Chart Method of Controlling Quality During Production. 35 pages; $2.50 per copy.

Formerly American War Standards, these three standards have been brought up-to-date with new reference material, new appendices, and consideration of one or two alternate statistical measures. American Standard Z1.1 outlines the basic concept and philosophy of the Shewhart control chart.

Step-by-step procedures are given along with examples of application. A definite criterion is provided for the character and quantity of information needed to insure statistical control. With such control, quality of the resulting product may be predicted with the highest degree of assurance.

Product Standards for Die Castings. *Standards listed below are separate pages, 8½ by 11 in., punched for three-ring binders. Copies are available at no charge from American Die Casting Institute Inc., 366 Madison Ave., New York 17, N. Y.*

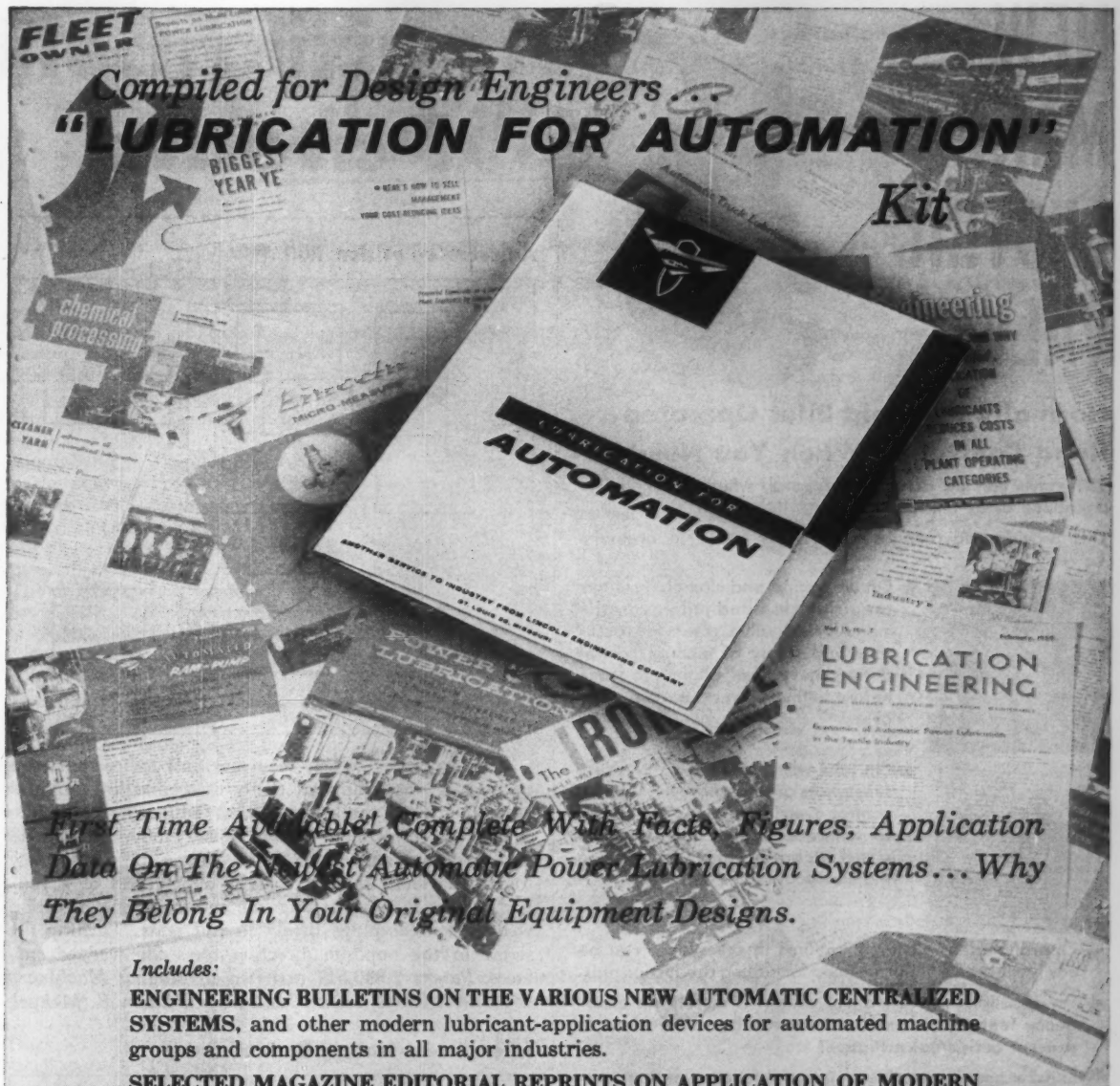
Die Cast Threads, ADCI-E14-59T. 2 pages.

Fillets, Ribs, and Corners, ADCI-E15-59T. 2 pages.

Lettering and Ornamentation, ADCI-E16-59T. 1 page.

Three new series "E" standards make a total of 16 engineering standards issued by ADCI to aid product engineers design toward the most economic level of die casting production. A complete set of product standards is available for $5.00 and includes 12 pages of the Metallurgical Series and 9 pages of the Commercial Series.

Circle 553 on Page 19



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NEW MANU-LECTRIC VALVE

Normally Solenoid Pilot Operated... Hand Controlled When You Need It!

The valve can be actuated by hand, whether the coil is energized or de-energized.

This provides advantages not usually found in ordinary valves:

★ On die setting and clamping set-ups requiring skill and judgment, the manu-lectric valve gives the accuracy and safety of manual control during the critical alignment stage before letting power operation take over.

★ On jobs where cement or powdery substances are handled, the manual control override enables the operator to "work" hopper doors and free a sticking batch without interrupting the electrical cycle.

★ Operational or electrical failures in the system can be easily checked without the need for halting production runs.

★ For situations where manual control is merely an emergency feature, the manual lever can be safety-wired to prevent accidental actuation.

Whether manual control is an integral function of your production set-up or called for only on rare emergency occasions, it will pay to install manu-lectric valves.

Compare the advantages... at so little additional cost!

½" Solenoid Pilot Operated Valve
1046AH Model $59.75
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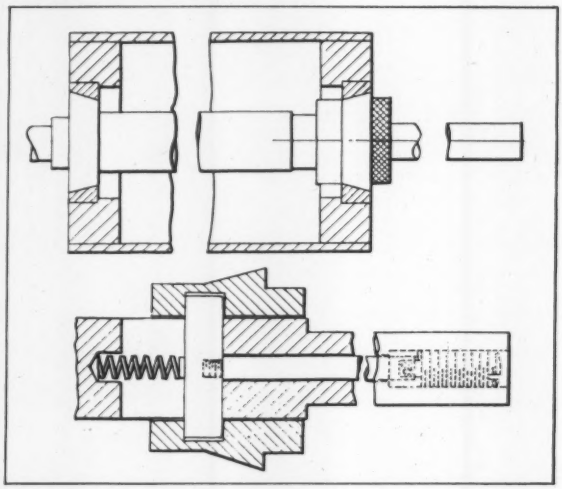
NOTEWORTHY

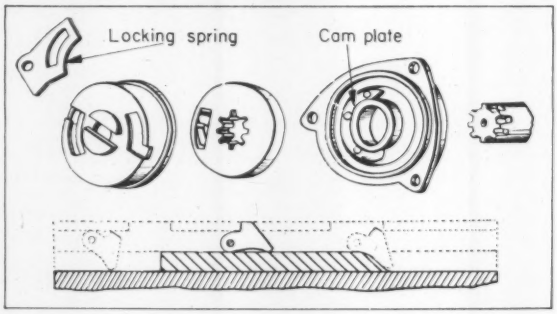
Patents

Adjustable-Position Roll



Wedging force which secures a roll to its shaft can be relaxed and reapplied easily to enable fine angular adjustments of the roll position with respect to the shaft. The adjustment can be made under heavy load and without removal of any parts. A pressure screw inside the shaft is turned in a pilot recess of a rod-and-bar member. Turning the screw in one direction wedges conical plugs firmly to roll ends. Turning the screw in the opposite direction frees the wedged surfaces. *Patent 2,890,517 assigned to Magnat Machinery & Pattern Corp., Leeds, Mass., by William R. Mengel.*

Intermittent-Motion Clutch



Continuous input rotation of driving members is converted to intermittent rotation of driven members at the rate of one-half output revolution per one input revolution. Once per input revolution, a pawl on the driving member rides a semicircular cam plate. The plate causes the pawl to engage one of two slots in an output cover and to carry the cover one-half revolu-

Electrolizing for *Reliability*

...an evaluation for engineers and metallurgists confronted with friction, wear, galling, and corrosion problems in critical components

What Electrolizing is... comparison with other bearing surface materials ...field service reports... an offer to treat test parts at no charge

Many frustrating problems involving premature failure of metal wear parts — or difficulty in meeting exacting specifications — are being solved every day by Electrolizing. Perhaps it holds an answer for you.

Electrolizing is a proved process that provides an unusual combination of bearing properties: remarkable wear resistance . . . an extremely low coefficient of friction . . . smooth sliding properties . . . excellent antiseizure characteristics . . . and beneficial corrosion resistance. Electrolized parts perform better and last 2 to 10 times longer than untreated ones.

What Electrolizing Does

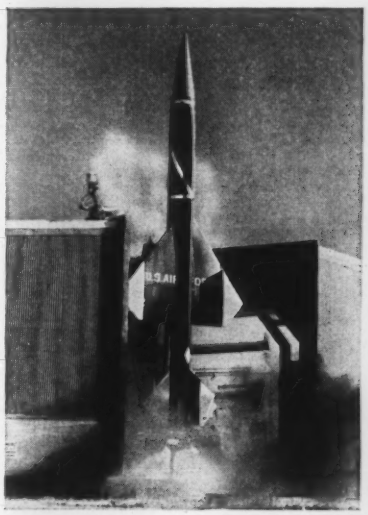
Electrolizing is specified where reliability is the most critical design consideration (such as on guided missiles, supersonic aircraft, atomic-powered submarines, and control and activating mechanisms). It shortens response time, increases efficiency, extends service life, increases lubricity, permits use of similar or like materials as opposing bearing surfaces, eliminates galling, and improves hydraulic sealing.

The Electrolizing process uniformly deposits a dense, high chromium, nonmagnetic alloy on the surface of the basis metal being treated. As deposited, this alloy has a hardness value of 70-72 Rc.

Thickness of the deposit ranges from .000025″ to .0005″. The problem involved and severity of service determines this. A thickness tolerance of ±.000025″ can be held on deposits up to .00025″. Not every application requires such precision, but every application benefits from the quality control that makes it possible. The microinch value of the basis metal is not measurably changed.

Comparison With Other Bearing Materials

In an exhaustive examination of more than 100 different bearing materials conducted by a recognized research group, Electrolizing took top honors in all categories. In a sliding test Electrolized stainless steel versus Electrolized stainless steel at 50 fpm, 60 psi, showed a coefficient of friction of only .001. In wear life studies, Electrolizing outperformed other highly regarded bearing materials as much as two or three to one.



Boeing Bomarc Missile

The reliability of Electrolizing is being confirmed constantly on some of the most critical and complex assemblies in missiles, atomic power plants, electronic systems, and ground support equipment. Ask for the Electrolizing "Check List of Proven Applications."

A copy of the complete report of this investigation is available upon request.

Field Service Reports

Electrolizing has saved the day on hundreds of applications ranging from hydraulic accumulators to roller chain. Here are two typical examples:

Helicopter mechanism — A rotor actuator assembly in a helicopter had been failing due to fretting corrosion in less than 50 hours of flight operation time. Strenuous demands were made for corrective action to insure flight safety. The actuator manufacturer tried every known "fix" without success. At this point, an Electrolizing engineering conference was requested. The failed parts were examined and certain recommendations were made. All of the moving parts in the assembly were Electrolized.

After two Electrolized assemblies each completed 1000 hours, the units were disassembled. No fretting corrosion occurred and no evidence of wear was observed. Electrolizing was approved for the application.

Aircraft instrument gears — A producer of aircraft instruments was unable to qualify an indicator due to premature failure of the high-speed gear caused by wear and loss of sensitivity.

Parts were submitted for Electrolizing and then assembled in three indicators for life cycle tests. At the end of 5000 cycles (mil spec test), no sign of wear or loss of sensitivity was found. After 30,000 cycles the indicators continued to meet requirements and, according to the customer, "engineering test has expressed some concern that their cycle counting device will wear out before the Electrolized indicators."

Questions and Answers

Pages 10 and 11 of the 24-page Electrolizing booklet give straightforward answers to the questions most commonly asked about Electrolizing.

They cover the fact that Electrolizing can be applied to all commonly machined ferrous and nonferrous metals... that it can be localized . . . that its properties remain unimpaired in temperatures ranging from —65° F to +1400° F (depending upon time at temperature) . . . that it has no adverse effect on the basis metal . . . and that it falls within a practical cost range.

If you do not have a copy of the Electrolizing booklet, just ask us for one.

Test Parts Treated at No Charge

You can find out at no cost and without obligation, if Electrolizing is the answer to your problem. Send us a few sample parts, a covering letter outlining the problem, and a drawing marked to indicate the critical area. These parts will be Electrolized without charge or obligation and returned to you for test. (Cutting tools, dies, fixtures, and molds are excluded from this offer.)

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DIVISION OF ADVANCE INDUSTRIES, INC.
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Circle 556 on Page 19

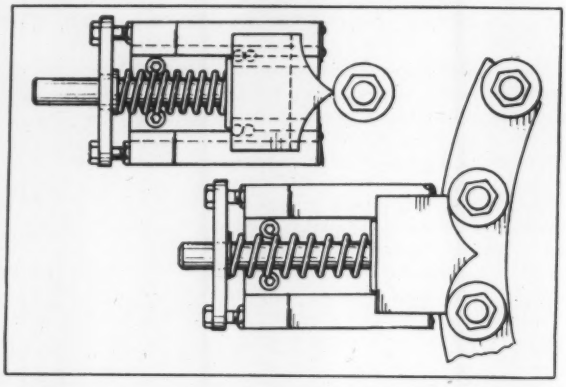
Concentration on design and production of quality ball bearings for all kinds of uses over a 50-year period has taught us a lot. Like how to move fast when sudden new engineering needs arise. How to keep production flexible when everybody wants everything right now. How much worth there is—to our customers and to us—in pride of workmanship and real understanding of a supplier's duty to meet "when-promised" delivery dates. If things like this make sense to you, talk to us about your ball bearing requirements, whatever they may be. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA BALL BEARINGS — BEARINGS COMPANY OF AMERICA

Circle 557 on Page 19

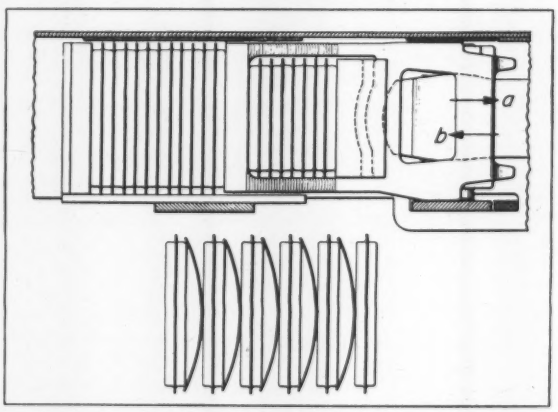
tion. In making this contact, the pawl displaces a locking spring which prevents rotation of the output cover during the half revolution when the pawl is not engaged. *Patent 2,889,712 assigned to Standard-Thomson Corp., Dayton, Ohio, by Paul F. Early.*

Indexing Mechanism Energy Accumulator

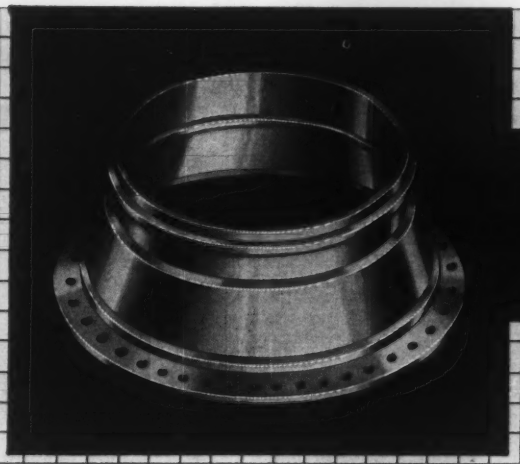


Supplementary in function to an indexing mechanism, a spring-loaded cam assembly releases energy during the first half of an indexing period and stores energy in the second half. This performance is due to the contour of the follower face—symmetrical, constant-acceleration curves. Accumulation of energy damps vibration as the indexing mass is brought to a stop. Release of energy aids acceleration, thereby reducing cycle time. *Patent 2,887,905 assigned to General Electric Co. by Kenneth W. Reynolds.*

Preloaded-Plate Cushioning Assembly



Stacked plates, half of them bonded with rubber, comprise a cushioning assembly which resists shock loads in either axial direction. Dished in shape at rest, the unbonded plates are alternately stacked with the bonded plates. All the plates are flat when the assembly is at rest. A rigid yoke divides the stack so that some plates resist shock in one direction *a*, and all resist shock in direction *b*. *Patent 2,889,056 assigned to Symington Wayne Corp. by Emil H. Blattner.*



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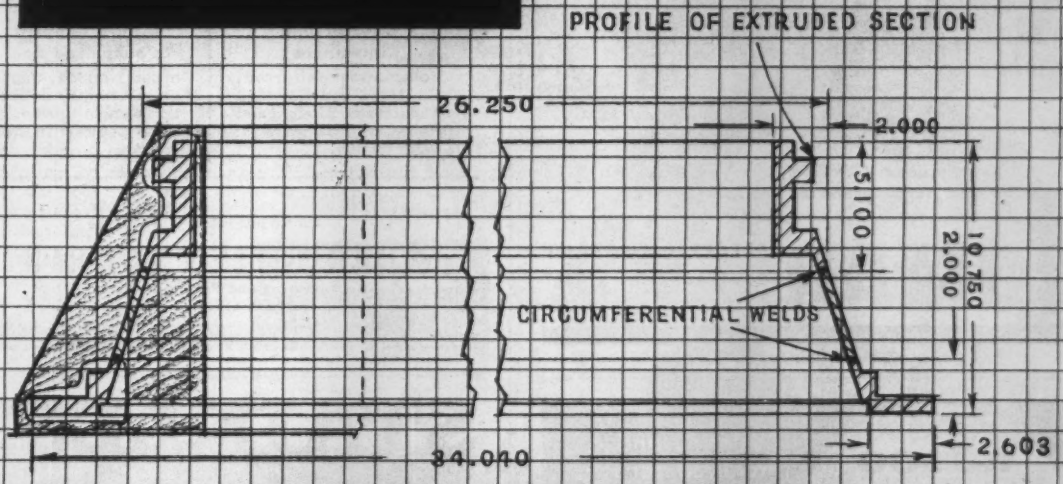

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Complete information. Facilities brochure, Precision Assemblies Catalog, and booklet on "How Flash Butt-Welded Rings are Made."

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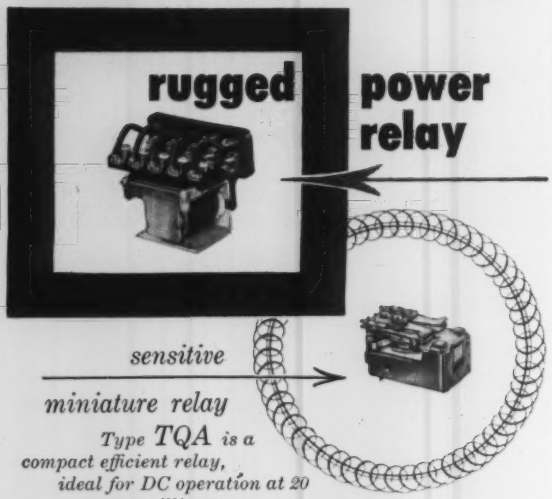
TYPE U general-purpose low cost power relay. Single coil construction, box-type magnetic field, movable contact springs. Contact forms from 1C to 5C. For AC or DC.



Type TQA is a compact efficient relay, ideal for DC operation at 20 to 100 milliwatt sensitivities. Hermetic sealing available. Send for details and free Comar catalog.

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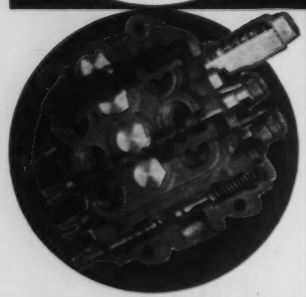

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- Four Positions of Control—Raise, Lower, Float, Neutral, with or without Detent
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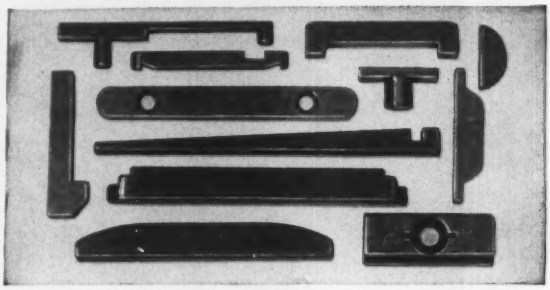

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Blueprints will receive prompt quotations
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Circle 560 on Page 19

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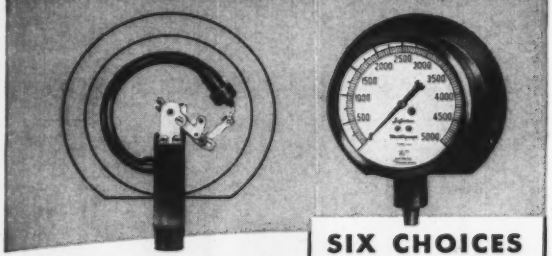

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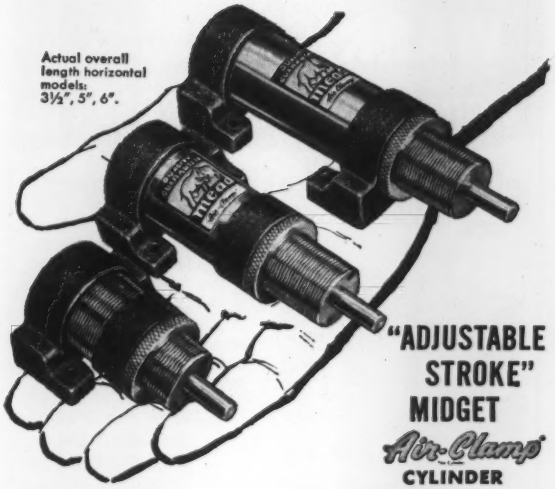

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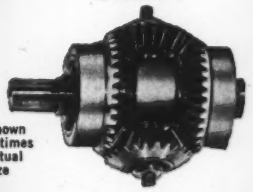

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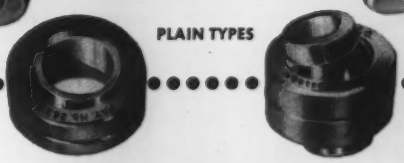

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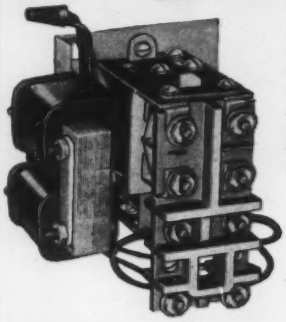

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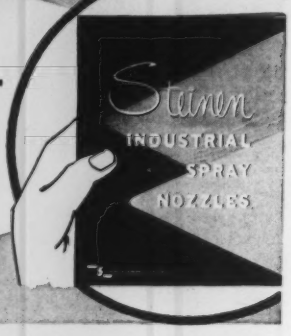

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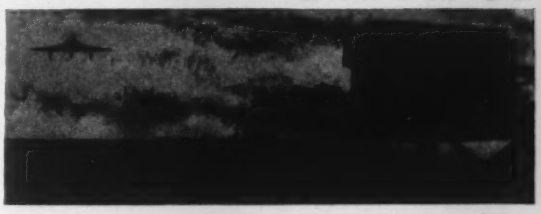

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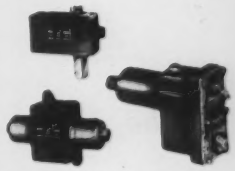

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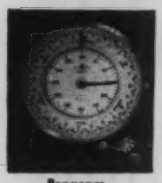

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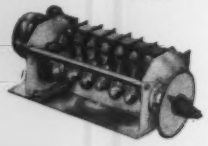

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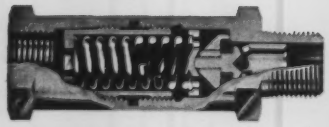

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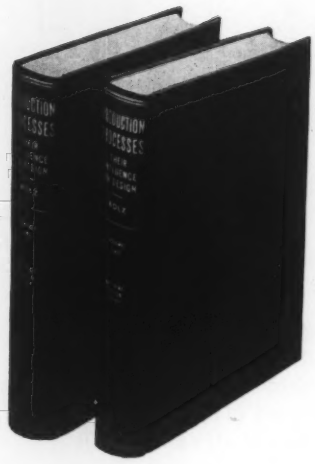

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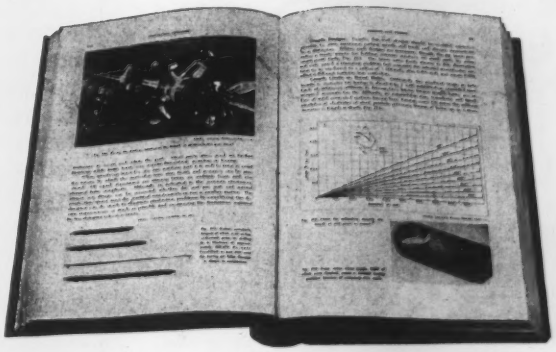

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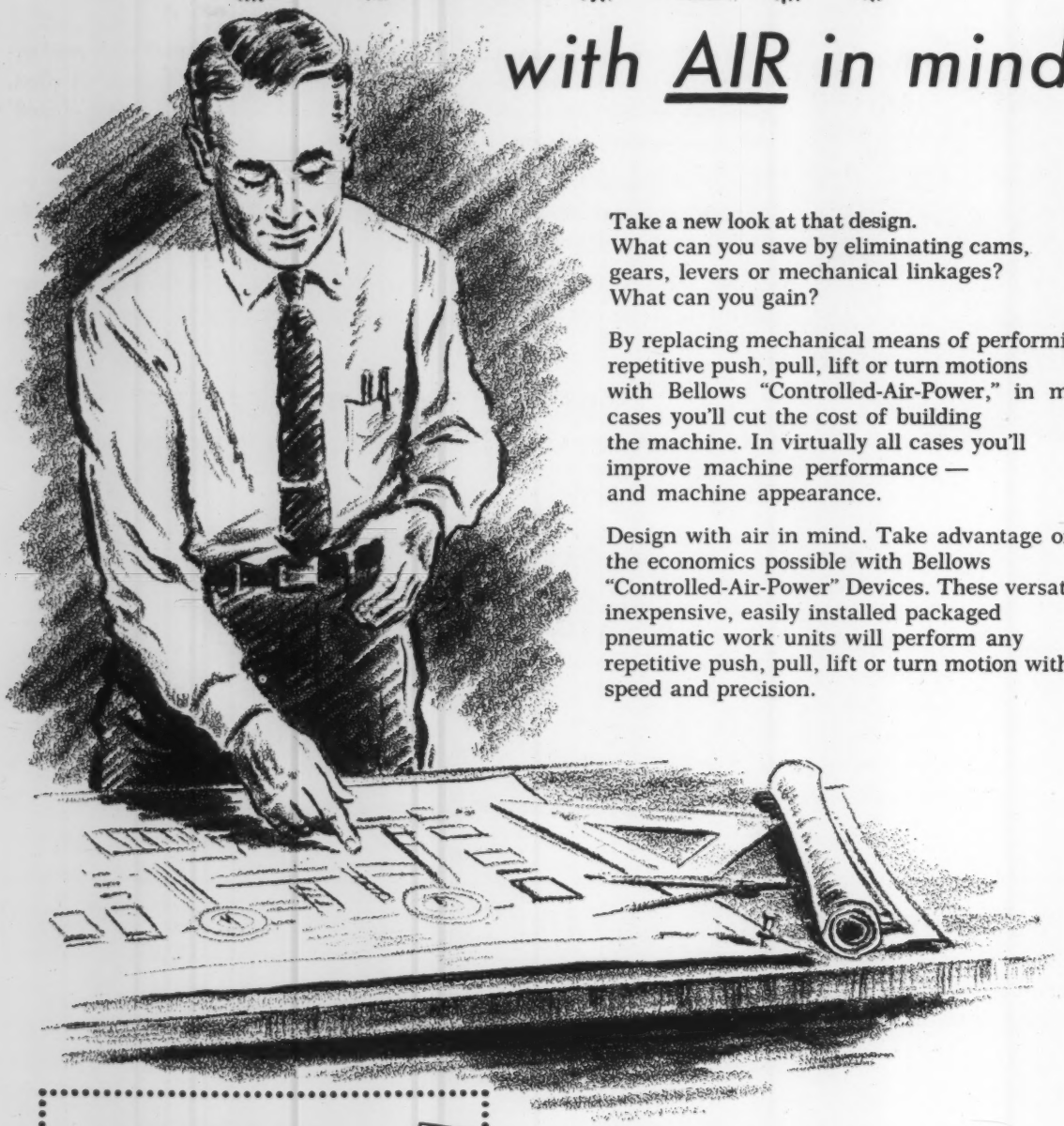

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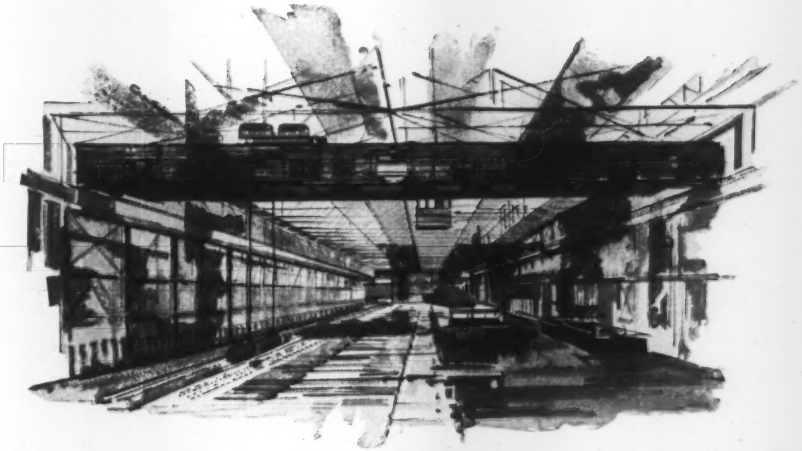

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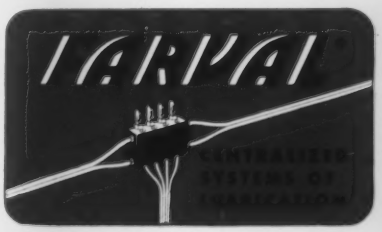

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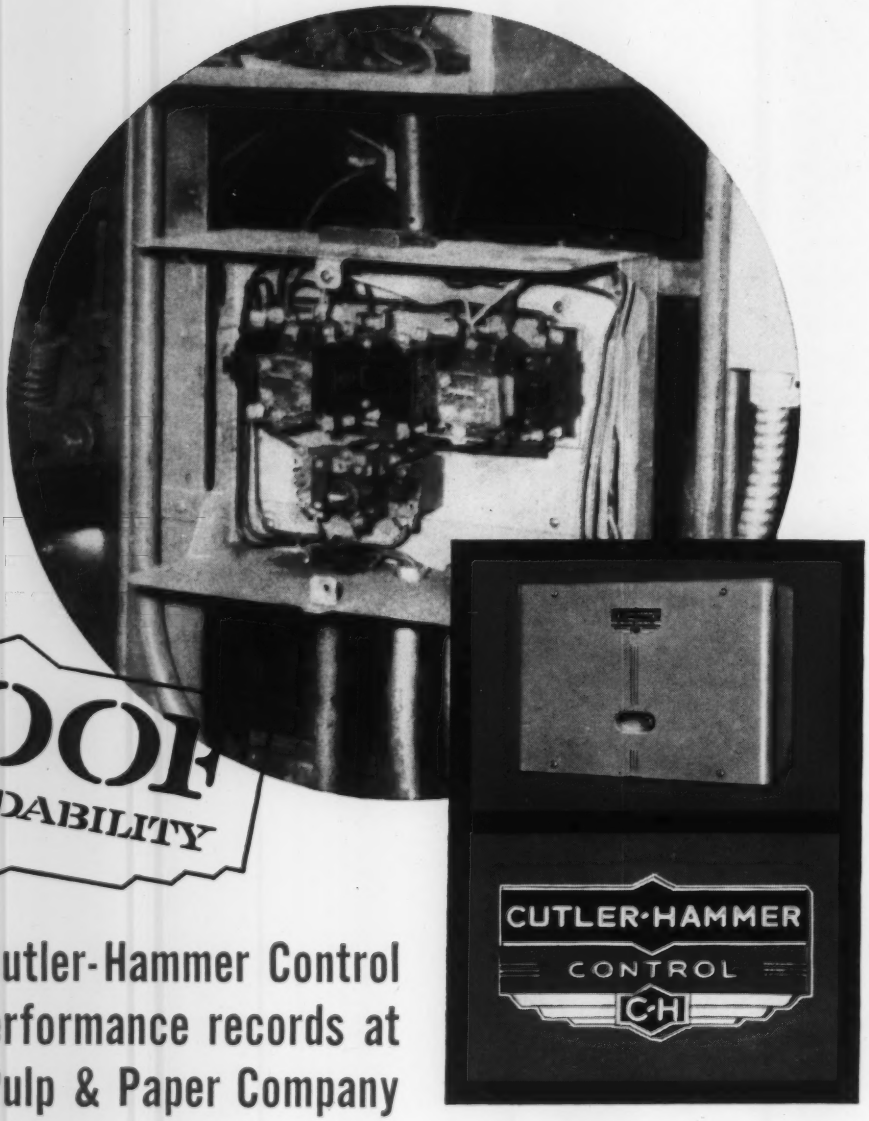

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